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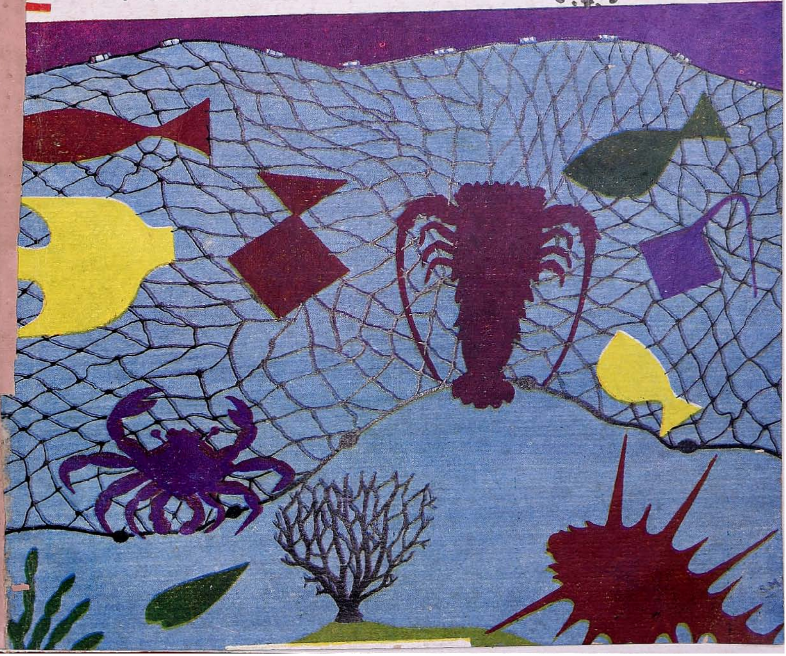

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FOREWORD

The Madras Fisheries Department has been in existence from 1907. A great deal of scientific work has been done by persons working in the Department ever since its inception. Some of this work is contained in papers printed by the Department separately and some of it got incorporated in issues of the Fisheries Bulletins. In the recent years the scientific papers have been included in the successive issues of the Administration Reports of the Fisheries Department. The Director of Fisheries had therefore suggested that it would be highly desirable to have a separate Journal of Fisheries which could be printed and published by the Fisheries Department itself. The Government accepted this proposal and directed that the Department of Fisheries should publish a journal of its own to be called, "THE MADRAS JOURNAL OF FISHERIES". This is the first issue of the journal. I am very glad to find that it contains a number of scientific papers both of academic importance as also applied value. I hope that the Madras Journal of Fisheries will constitute a welcome addition to the growing volume of scientific literature produced in our country.

MADRAS,
31*st* *December* 1964.

G. Bhuvarahan

(G. BHUVARAHAN),
Minister for Information and Publicity.

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BIOLOGY AND FISHERIES OF BARBUS DUBIUS (DAY) IN THE BHAVANISAGAR RESERVOIR

BY

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Huet (1959) relates the various problems in fish management to the Profile and Biology of Western European streams. He classifies European rivers into four zones, and zones comparable to these can also be distinguished in Indian rivers. The trout zones of brooks with deep gradient and rocky bottom are seen in our high altitude trout waters where cultural operations are practised. The greyling zone with rapids and pools, stream bed of pebbles, and boulders washed by current is comparable to our submountainous river stretch with a fishery of *Barbus tor*. The Barbel zone, an area alternating with rapid water and pools, stream with erosion and deposition banks, rocky and gravel beds alternating with sandy stretch, harbour the species—*Barbus dubius, Barbus carnaticus, Labeo kontius, Macrones aor* and *Wallagonia attu*. The last zone, viz., the Bream zone is typical of our deltaic stretches with slight water current, shallow sandy beds, and high summer temperature abounding in carps of the genera *Catla, Labeo* and *Cirrhina*. Many of the multipurpose reservoirs in India are constructed in the second or third zone listed above, originally impounding the fishes of the genus *Barbus*. Hence, a study of the Biology of the genus in the newly-formed reservoir conditions with special reference to growth and repopulation factors are of immediate practical importance. The effects of Dams on Fisheries have been discussed in a general way by Hora (1942, 1947, 1947-ab, 1948 and 1949) and Job et al (1955) and David and Motwani (1952).

Barber (1940) had observed thousands of fingerlings of *Barbus tor* ascending the provisionally constructed fish ladder at Mettur during the construction of the reservoir across the river Cauvery. There have been no catches of this species during all these years of exploitation at Mettur, in spite of the thousands impounded. *Barbus dubius* which was a favourite fishery in that river stretch and formed 5 per cent of the catches in the initial stage grew to good size, but failed to repopulate. The same fishery has successfully established itself in Bhavanisagar reservoir and it is also reported that it forms a good percentage of the landings from Krishnarajasagar.

There is no complete record of the Biology of any one of the species of *Barbus*. Observations on the breeding habits and migration of *Barbus tor* have been made by David (1953), Macdonald (1948), Hora (1940-b) and Wilson (1920). Hora and Nazir Ahamed (1946) records the suitability of *Barbus tor* and *Barbus hexagonolepis* for pond culture of the hilly tracts of Assam and East Bengal. Menon *et al* (1959) in their studies on the bionomics of the various fresh water fishes recorded that *Barbus dubius* formed 10 per cent of the fishery at Mettur and 60 per cent at Bhavanisagar. Very likely these observations relate to the period ended 1952 to which the report relates. Even then, the data for the figures from Mettur and Bhavanisagar do not justify this percentage. The particulars of fertilised egg and incubation period also do not seem to be correct and the distinguishing features by which the eggs were identified and worked upon are not furnished. The systematic position of the genus has been fully discussed by Hora (1940-b).

Material and Methods.

The material for this investigation was available in plenty from the daily landings of the Bhavanisagar reservoir. The observations on food and feeding habits, age, growth and breeding habits are with reference to this ecological condition. Comparisons were also made with the specimens collected from the river system above and below the Dam. From 1955 onwards specimens of *Barbus dubius* numbering over 25,000 have been examined at various stages. Specimens with mutilated caudal fins were rejected (Seshappa and Bhimachar 1955). Measurements of length were taken correct to the nearest millimetre and in the fresh condition. The total length was taken from the tip of the snout to the end of the longest caudal ray. Besides the length, the individual weights were also recorded. Histograms of these lengths were drawn to have an idea of the trend of this fishery in the newly impounded reservoir. Since 1961 scales were taken from all specimens from the left side of the body below the dorsal fin and above the lateral line, recording simultaneously the total length, gonadial condition and stomach contents. Regenerated scales were discarded and only the best scales were selected. After clearing, they were mounted on a glass slide and examined under a powerful lens. The scales were also projected and the length of the scales, anterior radius (from the focus to the anterior edge) and the distance between the focus and each year ring were all measured to the nearest millimetre.

Description of the Bhavanisagar Reservoir.

The Bhavanisagar reservoir has a water spread of 30·41 square miles at the full reservoir level of 920 feet M.S.L. impounding 28,000 million cubic feet of water. It is formed by the damming the river Bhavani after its confluence with river Moyar, both arising from the Nilgiris (Fig. 1). The average yearly inflow of the two rivers is 1,000 cusecs. During the South-West Monsoon (June to August) and North-East Monsoon (November to January) the inflow increases to 10,000 cusecs and this has an important bearing on the repopulation of the fishes breeding both in South-West and North-East Monsoon periods. The bed level of river Moyar as it enters the reservoir is

905 M.S.L. and it gradually slopes down to 805 M.S.L. as it joins the river Bhavani. The M.S.L. of the river bed after its confluence at the Dam site is 802. The bed level of the river Bhavani as it enters the reservoir is 905. There are no falls or barriers at the commencement of the reservoir. At various contour levels, the spread of the water in relation to the entry of the river into the reservoir is such that there are no falls or barriers preventing the free migration of fish to the river stretch above. The sill level of the exit regulators of the canal after damming is + 840 and this ensures a perennial storage in spite of adverse conditions. The following are the details of water storage and spread at different levels:—

Contour level.	*Area submerged in acres.*	*Water storage in M.C.F.T.*
(1)	(2)	(3)
+ 840 M.S.L.	1,608·3	5,461
+ 880	8,594·8	8,879
+ 915	17,955·85	28,726
+ 920	19,463·80	32,799

The dispositions of the contour lines of 920 feet, 915, 880 noted in the sketch (Fig. 1) give an indication of the terrain of the area submerged. A few depressions on account of mountain feeder streams joining the original river are seen. The north-east half of the submerged Moyar spread was once a reserved forest now completely denuded, and operation of drift nets at all contour levels is easily possible. Between the dam and the river Moyar is the old Peerkadavu village. The western area submerges the old Dananarankottai village, with its temple and is bounded by the eastern slopes of the Nilgiris which slopes to the Bhavani river bed level from 930 to 820, the contour line taking some changed course on account of the hilly area. The eastern half of the reservoir has the same sloping contour gradually leading to the Panchayat Forests and the village. Except for the submerged temple and a few rocky hills getting exposed at various levels, there are no fishing impediments at any contour level. The two rivers have a long river stretch above the reservoirs. Emerging out from the hills, they are fast flowing rivers with rapids and pools, beds strewn with pebbles and occasional sandy patches. Wilson (1920) has recorded the importance of this stretch as breeding grounds of fishes for conservation. *Barbus tor*, *Barbus hexagonolepis*, *Barbus dubius*, *Barbus carnaticus*, *Labeo kontius*, *Labeo ariza*, *Wallagonia attu*, *Macrones aor*, *Macrones seenghala* and *Ophiocephalus striatus* are the fishes of economic importance recorded by various workers of the Madras Fisheries in this stretch as well as the now submerged river stretch.

An Account of the Fishery of the Reservoir.

The reservoir impounded water since 1955. The fishery is now conserved along with a programme of stocking with the well known Indian Carps Rohu, Mrigal and *Catla*. Since 1957 a unit was made to fish daily at various places marked in the map. The unit consisted of four fisher men laying 2,500 running feet of synthetic yarn Rangoon nets of varying meshes and hauling them up next morning. The catches were analysed in detail, length of each fish recorded and the gonadial condition observed. An analysis of these *observations is expected to reveal the trend of growth and* repopulation of each species-indigenous and exotic to the reservoir and of practical application in the management programme of the multipurpose reservoirs. The following are the more important species of fishes, their numbers and weight landed by the experimental unit. It is seen that the trend of *Barbus dubius* fishery is one of growth and repopulation. The histogram picture of 2,000 fishes, in 1957 (Fig. 2) reveals a limited exploited age group while the 1961 (Fig. 4) picture shows age groups of all the VI year classes. In view of the space offered, planktonic food and the benthic fauna on the margins, there was quick growth. Since, by 1957 the reservoir was two year old the exploited group ranged up to the fourth year class. By 1961 (Fig. 4) the V, VI and VII year classes have appeared as was expected. The fishery constitutes 1/5 of the total fishery and thus assumes major importance in reservoirs of the Bhavanisagar type (Photo 1).

Quantity and species of fish landed by the experimental unit at Bhavanisagar.

Year.	*Barbus dubius.*		*Macrones aor.*		*Labeo fimbriatus.*		*Labeo calbasu.*		*Catla catla.*		*Wallago attu.*		*Labeo kontius.*	
	Number.	*Weight in Kg.*	*Number.*	*Weight in Kg.*	*Number.*	*Weight in Kg.*	*Number.*	*Weight in Kg.*	*Number.*	*Weight in Kg.*	*Number.*	*Weight in Kg.*	*Number.*	*Weight in Kg.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1956–57 ..	4,015	4,838·9	4,428	713·0	13	15·2	..	..	..	64·3	..	..	102	865·22
1957–58 ..	2,805	4,667·5	847	2,380·0	215	15·65	..	..	9	88·5	..	..	125	88·9
1958–59 ..	2,344	4,542·6	514	849·3	28	20·9	..	..	..	..	..	..	128	91·2
1959–60 ..	2,166	4,425·0	1,152	2,230·5	170	585·4	..	..	43	558·0	..	..	273	294
1960–61 ..	2,882	5,219·0	3,367	6,152·0	620	1,479·0	318	1,203·8	134	1,203·8	453	581·2	324	356·3

Food and Feeding Habits.

Over 250 specimens of the fish were examined to determine its food and feeding habits. The fish has a protrusible mouth very typical of the Masheer family and adapted to hill stream conditions. This adaptation helps it to turn, the pebbles, sand and mud and feed on fresh water Oligo. chaetes, Chironemids, and gastropods. In addition, it also feeds on the Zoo and*Phyto-plankton in the reservoir* *Pediastrum*, *Nitzchia*, *Navicula* and *Melosira* being more

common. The gill rakers are slightly developed to filter the plankton organisms. There are well developed buccal *glandular thickenings secreting* mucous *to guide the filtered* plankton food to the pharynx. The guts of the specimens during October to December are not always full. Plankton food is more dominant during these months and there is very little of the bottom fauna. From January onwards the fishes commence an active feeding period usually shoaling along the margins and in the top waters at a depth of 5 to 15 metres. The alimentary canal of these specimens at this stage is clogged with Chironomids, fresh water oligochaetes, gastropods, and broken insect wings and appendages. There is no reason to suggest any direct relationship between the occurrence of any special type of food forms in the reservoir or top waters leading to mass migration. In general, the fish is a bottom feeder and restricts itself to the 5 m. to 15 m. belt of the reservoir rich in chironomids, fresh water oligochaetes and gastropods and also helps itself to all the available plankton food in the reservoir (Chacko 1956).

Age and Growth

A knowledge of the year class composition of *Barbus dubius* fishery is extremely important for studying its trend and to decide the management policy. This is possible only if the age and growth are determined. The age and growth of *Barbus dubius* have been studied by the following methods :—

(i) By analysis of the length frequency distribution of the catches from the experimental unit at Bhavanisagar; and

(ii) by a study of certain rings *that occur in the scales* of this fish and which have been found to be indicators of age. Scales have been used for the estimation of age of tropical fishes with varying degress of success, Jhingaran (1959) Pantulu (1961) Seshappa and Bhimachar (1954 and 1960). The rings occured repeatedly in all specimens of 250 mm. and above. It was considered useful to find out reliably the exact frequency of the occurrence of these rings in the different size groups and several random samples were examined in detail. The information obtained from 30 of the 180 observations is summarised below:—

Length of fish in mm.	*Radius in mm.*	*Number of rings.*	*Distance from the centre.*
(1)	(2)	(3)	(4)
300—309	4·5	2	4·5
310—319	4·5	2	4·5
320—329	4·7	2	4·7
330—339	5·0	2	5·0
340—349	5·0	2	5·0
350—359	5·5	2	5·0
360—369	5·7	2	5·0
370—379	6·0	2	5·0
380—389	6·3	2	5·0
390—399	6·3	2	5·0
400—409	6·5	2	5·0
410—419	6·7	2	5·0
420—429	6·7	2	5·0
430—439	7·0	3	7·0

Length of fish in mm.	*Radius in mm.*	*Number of rings.*	*Distance from the centre.*
(1)	(2)	(3)	(4)
440—449	7·2	3	7·0
450—459	7·5	3	7·0
460—469	7·5	3	7·0
470—479	7·9	3	7·0
480—489	8·3	3	7·0
490—499	8·5	3	7·0
500—509	8·5	3	7·0
510—519	9·1	4	9·0
520—529	9·3	4	9·0
530—539	9·5	4	9·0
540—549	9·5	4	9·0
550—559	9·7	4	9·0
560—569	10·1	5	10·0
570—579	10·2	5	10·0
580—589	10·3	5	10·0
590—599	10·5	5	10·0
600—609	11·0	5	10·0
610—619	11·2	6	11·0
620—629	11·3	6	11·0
630—639	11·5	6	11·0
640—649	11·0	6	11·0
650—659	11·8	7	11·8
660—669	12·0	7	12·0
670—679	12·0	7	12·0
680—689	12·3	7	12·0

There were no rings in specimens below 250 mm. The scales of *Barbus dubius* are ovolanceolate in shape with a central granulated nucleus. A camera lucida drawing of the scale Fig. 16. with the growth ring is figured in the diagram. The rings appear clearly during the breeding period October to December and from January onwards, the scales develop uniformly and actively beyond the rings. The correlation of the rings to the 'breeding' stress is interesting inasmuch as no environmental lack of food has been observed. Menon and Krishnamoorthy (1956) tried to determine its age and growth. Whatever may be the cause of the variation in the rate of growth leading to the ring formation, the fact remains that the ring is annual in nature and can be used in determining the age of the fish. From the table already presented, the length of the rings from the focus is derived as follows :—

I Ring	3 m.m.
II Ring	5 m.m.
III Ring	7 m.m.
IV Ring	9 m.m.
V Ring	10 m.m.
VI Ring	11 m.m.
VII Ring	12 m.m.

The observed mean length, range and its relationship to the annulus is expressed in the following table:—

Annulus.	*Age in years.*	*Mean length in m.m.*	*Range in m.m.*
1.	I	250	0—270
2.	II	360	270—390
3.	III	440	380—470
4.	IV	520	450—540
5.	V	570	510—590
6.	VI	620	570—630
7.	VII	670	620—680

It would appear that the first ring is seen in fishes of average length 250 mm. Second 360 mm. Third 440, fourth 520, fifth 570, sixth 620 and seventh 670.

Body Scale Relationship.

The reliability of the above data were tested against a detailed study of the body scale relationship. The length of the scale increases with the increase in length of fish. This is illustrated in the Text Fig. 5 which shows a straight line relationship. This relationship is expressed by the general formula.

$Y=a+bx$. where ;
Y=Length ;
X=*Scale Radius* and ;
a and b are constants.

In this present work, the regression formula was calculated to be

$L=139{\cdot}36+43{\cdot}7x$
L=Total length of fish; and
X=Scale Radius.

In Fig. 6, this straight line cuts the Y axis at 139 mm. In this population, it is determined that the scale radius is visible when the fish is about 139 mm. in total length. This was actually found to be correct in *Barbus dubius.* The radius is visible when the fry are 139 to 140 mm. and proves the correctness of the formula.

Using this regression formula, back calculation was made to find out the lengths reached by the fish at the formation of various rings. [Fig. 7.]

Calculated Lengths are given below :

I Year	.. ..	270 m.m.
II Year	.. ..	357 m.m.
III Year	.. ..	445 m.m.
IV Year	.. ..	532 m.m.
V Year	.. ..	573 m.m.
VI Year	.. ..	619 m.m.
VII Year	.. ..	660 m.m.

The comparison between the observed lengths from size, frequency and ring groups and calculated lengths of fish is expressed in the following table:—

Age in year.	*Observed length from Histogram* M.M.	*Observed length from Ring Groups* M.M.	*Calculated length* M.M.	*Number of Ring.*
(1)	(2)	(3)	(4)	(5)
I	250	250	270	1
II	350	360	357	2
III	430	440	445	3
IV	510	520	532	4
V	570	570	573	5
VI	610	620	619	6
VII	660	670	660	7

Agreement with Peterson's method.—Agrement with Peterson's method is one of the tests of validity for the use of any structure for age and growth determination. As is well known, in a population of a species of fish having a single restricted spawning season, the individual lengths of fish of each age group are approximately normally distributed and the modes of the length frequency distributions of successive age groups in a sample are separated along the length axis. In *Barbus dubius* these conditions are almost completely satisfied in that the fish has a *single spawning season, during October* to December. A frequency diagram of 2,000 specimens collected during all the months for the year is shown in Text Fig. 4 The different age groups in the polymodel frequency distribution were separated by the eye method (M.D. & B.K.). The 'O' group individuals were not represented in the length frequency histogram as they formed the prerecruit phase in the fishery and hence did not appear in commercial catches. As is evident from the table there is a high degree of agreement between age estimation, by the scale method and length frequency studies.

The observed mean lengths, calculated lengths and the radius of the scales is illustrated in Fig. 6.

Growth in Length.

The table below (Table IV) presents the growth in length and its increments at the end of each year and is further illustrated in Text Fig. 7 (*a*) and 7 (*b*).

The growth increment in length of *Barbus dubius* fish decreases in the second year and it increases in the third or fourth year. After that the growth gradually decreases.

TABLE IV.

Age Groups.	*Average length in m.m.* I	II	III	IV	V	VI	VII	*Average increment in m.m* I	II	III	IV	V	VI	VII
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
II ..	230	334						239	95					
III ..	206	308	424					206	102	116				
IV ..	183	304	402	463				183	121	98	61			
V ..	197	296	420	500	561			197	99	124		61		
VI ..	151	300	404	514	578	624		151	149	102	110	64	46	
VII ..	156	298	387	491	573	626	670	156	142	89	104	82	53	46

Length-Weight Relationship.

In order to find out the length weight relationship the individual weights and measurements of 100 specimens ranging from 300 mm. to 680 mm. were recorded. These 100 fishes were divided into 6 groups. The average length

and weight for each group were calculated. A scattered diagram of weight and length (Text Fig. 8) suggested that the relationship conformed to the general formula.

W=CLn. where,
W=Weight,
L=Length and,
C and n are constants.

The logrithamic formation of this equation is,
Log W = log c+n log L.

The value of log 'c' and 'n' were determined from the following normal equation :—

$$\text{Log } c = \frac{\Sigma \log W . \Sigma (\log L)^2 - \Sigma \log L\, (\Sigma \log L . \log W)}{N . \Sigma (\log L)^2 - (\Sigma \log L)^2}$$

$$\text{and } n = \frac{\Sigma \log W - N \log C}{\Sigma \log L.}$$

In this present work the equation worked out to log W=7·333+3.878 log L.

Text Fig. 8 illustrates the calculated weights against the lengths.

Growth in Weight.

The table below shows the increment of fish in weight at the end of each year. It shows that the fish grows in weight rapidly from the second year onwards. This *increment in weight is illustrated in the Text Fig.* 9 and 10.

TABCE V

Age Groups.	*Average weight in grams.* I	II	III	IV	V	VI	VII	*Average increment in grams.* I	II	III	IV	V	VI	VII
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	15)
II ..	77	355						77	278					
III ..	44	207	719					44	163	512				
IV ..	28	198	585	1,016				28	170	387	431			
V ..	37	178	687	1,371	2,623			37	141	509	684	1,252		
VI ..	18	187	585	1,583	2,495	3,214		18	169	398	953	957	719	
VII ..	15	182	498	1,250	2,275	3,214	4,236	15	167	316	752	1,025	939	1,022

Relative Condition.

Relative condition factor or Kn was calculated by using the formula $K=\frac{W.10^5}{L^3}$ It was calculated for individual fish, of six groups, Table VI.

The table VII presents calculated K factor for individual fishes, male and female separately for the months of October, November, December and January.

TABLE VI.

RELATIONSHIP BETWEEN LENGTH AND WEIGHT OF BARBUS DUBIUS.

Number of years.	*Mean weight in grams*	*Mean length in m.m.*	$K=\frac{W \cdot 10^5}{L^3}$
(1)	(2)	(3)	(4)
1, 2	455	363	0·9513
2, 3	975	445	1·109
3, 4	1,527	515	1·118
4, 5	2,335	577	1·215
5, 6	3,017	619	1·272
6, 7	3,505	675	1·140

Compared to other carps the gonads occupy very little space and form a very small portion of the weight of the adult fish as a whole.

The ground averages of K. are presented below. It shows that the relative condition is less than '1' in the second year. From second year onwards it increases gradually and reaches its maximum value in fourth to fifth to sixth year. From sixth year onwards, it decreases.

Comparison of this table V with the Text Figs. 9 and 10 shows that the growth in weight reaches its maximum value in the fifth year which coincides with the greater value of K. at that age.

TABLE VII.

Month.	*Male.* *Number,*	*Length, m.m.*	*Weight, g.m.*	*K*	*Female.* *Number,*	*Length, m.m.*	*Weight, g.m.*	*L,*
(1)	(2)	(3)	(4)	(5)	(6)	(6)	(8)	(9)
October	1	405	700	1,053	1	345	400	0·8574
	2	430	800	1,006	2	360	400	0·8574
	3	536	1,500	0·9738	3	527	1,650	1·127
	4	575	2,500	1·314	4	530	1,600	1·074
	5	645	3,400	1·267	5	576	2,250	1·178
					6	605	3,100	0·705
					7	614	3,000	1·296
					8	680	4,500	1·431

Month.	Male, Number.	Length. m.m.	Weight. g.m.	K.	Female, Number.	Length. m.m.	Weight. g.m.	L.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	1	448	1,000	1·112	1	435	900	1·093
	2	480	1,200	1·086	2	505	1,500	1·165
	3	494	1,000	0·644	3	555	2,200	1·286
	4	545	1,700	1·079	4	610	2,500	1·162
	5	590	2,600	1·269				
	6	645	3,500	1·304				
December	1	445	1,000	1·134	1	410	800	1·161
	2	550	1,700	1·052	2	420	800	1·144
	3	570	2,000	1·000	3	460	1,050	1·104
					4	520	1,600	1·138
					5	665	3,000	1·021
January	1	295	400	1·559	1	422	850	1·331
	2	435	600	1·042	2	450	1,300	1·427
	3	435	850	1·032	3	452	1,000	1·083
	4	460	1,000	1·027	4	460	1,100	1·130
	5	462	1,100	1·116	5	465	1,150	1·144
	6	482	1,300	1·135	6	480	1,300	1·176
	7	492	1,400	1·250	7	510	1,500	1·193
	8	500	1,400	1·119	8	515	1,500	1·098
	9	520	2,300	1·639	9	530	1,900	1·277
	10	560	2,200	1·252	10	630	3,000	1·111
	11	597	2,310	1·085	11	635	3,000	1·092
	12	615	3,100	1·332	12	650	3,000	1·384
	13	642	3,600	1·352				

Maturation, Fecundity and Spawning.

The scale adopted by Hjort was followed to distinguish the different stages in the maturity of the fishes. The fishes attain maturity only once in a year with a marked spawning season extending from October-November to December coinciding with the North East Monsoon. The species become gravid only from the second year onwards. They do not spawn in the reservoir but migrate upwards and spawn in the river stretch. The males ripen earlier and start their upward migration and are followed by the females. Because of this, there is an apparent percentage difference of sex ratio in the catches. The October catches are predominantly male while the December catches are female. However, after the spawning season is over, the catches exhibit an equal number of females and males. Stage I of maturity in females is seen in the catches of late September. By the end of October, stage V is reached. Once the North East Monsoon sets in and the the floods come, upward migration starts and the spawning grounds are full of breeders. On gentle pressure, the ova come out, the individual ovum being transparent and ripe. So far as Bhavanisagar is concerned the spawning grounds are easily accessible irrespective of the water spread. The grounds are the river stretch immediately above the reservoir. The mature adults take shelter in the clear pools between two shallow rapids. Fishes caught from these pools are in VI stage. On handling the ripe ova run out and fish lends itself to stripping and artificial fertilisation.

This sexual dimorphism of the fish has been described by Choodamani and Thyagarajan (1959.)

	Male.	*Female.*
Pearl organs (Tubercles on the cheek).	Large member and greatly enlarged	Few and nil in large specimens.
Anal fin	Smaller than pectorals and equal to or smaller than ventrals.	Larger than both pectorals and ventrals.
Ventral	Smaller than pectorals and equal to or slightly larger than anal.	Smaller than both anal and pectoral.

Their statement that in *Barbus dubius* females attain bigger size than the males is not borne out by our observations in the reservoir.

The pronounced appearance and even enlargement of the tubercles as maturity advances in males is marked. During spawning, a translucent plate bearing the

impression of the tubercles peels off, from the cheeks. The just spawned males can be easily identified by the fresh surface of the tubercular cheek. No such peeling off is observed in females.

Fecundity.

The fecundity of the fish is poor compared to other major Indian Carps. The following are the estimated number in four of the females collected near the spawning ground :—

Length of the fish.	*Weight in grams.*	*Volume of ovary.*	*Weight of ovary.*	*Number of ova.*
(1)	(2)	(3)	(4)	(5)
		cc.	gr.	
·603	3,650	85	87	66,568
·612	3,668	88	92	65,340
·608	3,614	80	·78	65,480
·605	3,645	78	72	65,279
·617	3,712	92	88	66,417

Alikunhi (1954) has recorded the fecundity of some species of carps as follows :—

Species.	*Total weight in grams.*	*Number of ova.*
(1)	(2)	(3)
Catla Catla	5,107·5	400,275
Labeo Rohita	4,653·5	1,905,000
Labeo Calbasu	1,816·0	739,400
Cirrhina Mrigala ..	1,475·5	216,800
Labeo bata	1,049·9	300,000

He has brought out the sizeable percentage of the ovary by weights and volume to the total weight of fish in the major carps.

The ripe ovary is inconspicuous in *Barbus dubius* compared to the weight of the fish. The gonadial maturity and sex affect very little the length weight relationship at any stage.

Spawning.—Barbus dubius spawns once in a year between October and December during the North East Monsoon. The fish exhibits a marked spawning migration. The favourite spawning grounds for the Bhavanisagar fishes are marked in Text Fig. 1. After taking shelter in the pools they move towards shallow areas and deposit the egg in batches in the gravel. Each batch consists of 1,000 to 2,000 eggs. At this stage, the fish are lethargic and are easily caught by the fishermen with their stringless cast nets and by diving. Even on handling, the milt and ova are shed out.

The river water here is characterised by high oxygen content, supersaturation as seen in the table. The substratum is full of pebbles and coarse grains.

Hydrological data of the Spawning Belt from where Oozing Breeders were Collected for Stripping.

Date—18th September 1960.
Time—11·00 a.m,
Temperature—27·8° C.
Free Co2—1·4 P.P.M.
Carbonate—Nil.
Bicarbonates—15·25 P.P.M.
Chloride—9·00 P.P.M.
Oxygen—9·8 Ms/L.
Oxygen per cent Saturation—120 per cent.
pH—6·7

(*Water slightly turbid*)

The fishery management at this stage calls for a complete prohibition of the top waters from any type of fishing. Heavy catches, by local fishermen, of 250 K g. a day were recorded of oozing *Barbus dubius* on many days in October and November 1960 and 1961. According to Chacko (1956) '*Barbus dubius*' migrates upstream during the floods of both the monsoons and spawns in the higher reaches of the river where the temperature is about 27°–30°C. and pH 8.0–9.8. The pH of a natural flowing water in the submountaionous area cannot be so high. Our observations at Bhavanisagar clearly reveal that the fish spawns only once in a year corresponding to North–East Monsoon.

Development.

A complete picture of the developmental stages was made possible by artificial stripping and fertilising the oozing adults caught from the spawning bed. A number of hatchlings were also collected from "reds" in the spawning area and reared for a month in the laboratroy and correlated with the stages reared from stripping.

The fertilised egg is perfectly spherical, with a glossy appearance of blue orange yellow. The phenomenon of swelling of the eggs after fertilisation observed in Indian Carps is not met with in *Barbus dubius*. The average diameter of the unfertilised egg is 1.6 mm. After fertilisation the perivitelline space expands a little. The average diameter of the fertilised egg is now 2.4 mm. (Photo 2). In the other Major Carps, however, the perivitelline space swells to 4 to 5 times against 1.7 mm (photo 3) of space. The fertilised egg of *Barbus dubius* is heavy, demersal and immediately sinks to the bottom, unlike the fertilised eggs of other carps which get drifted and consequently get caught in spawn nets. This heavy character of the fertilised egg has a bearing on the distribution of the species to sub-mountainous zones only.

Twelve hours after fertilisation the headfold gets differentiated (Fig. 11). Twenty-four hours old egg clearly brings out the tailfold and the embryo at this stage is 0.30 c.m. Now the headfold and tailfold become clearly differentiated from the yolk. The rudiments of the eye appear but there is no pigmentation anywhere (36 hours old-Fig. 12). Seventy two hours after fertilisation the embryo hatches out and the uncouth alevins with the big yolk sac, are long (Fig. 13). The yolk sac has become long and tubular with a swollen rounded anterior portion and a tubular posterior portion constricted in two places. The median finfold has appeared

and the larval tail is flat and transparent. The rudiments of vertebral column are formed. The eyes develop slight pigmentation. With the formation of the pericardium, the larval blood circulation commences. The hatchling is 4 m.m. when 96 hours old. The eyes develop pigmentation. The embryonic vertebral column is distinct and the rudiments of the brain have been differentiated. The swollen anterior portion of the yolk remains unchanged, while the tubular portion shrinks considerably. The pericardium has been differentiated into a larger anterior and a narrow posterior chamber. The rudiment of the stomach has been formed.

On the fifth day after hatching the larvae are long, the mouth has opened and the larval stomach and anus are differentiated clearly. A portion of the yolk sac still remains unabsorbed. The gill slits have opened out and there is an active flapping of the opercle. The paired pectorals are active now. The eyes are deeply pigmented as also the dorsal portion of the head. There are scattered rounded pigments on either side of the mid-dorsal line as far as the peduncle.

By the tenth day, the hatchlings are long, a distinct caudal blotch has appeared tending to be more prominent in the lower half. The dimunitive dorsal fin as also the paired fins and the anal fin are well formed. The yolk is completely absorbed. Barbels have not yet appeared.

When larvae are 1.3 to 1.4 cm. long rudiments of scales appear along with barbels. The fry now move out in batches yet restricting themselves to the eddies and shallow areas of the spawning belt. By about February, the entire shallow area near the spawning beds is full of these fry in various stages of growth. It is possible to make large scale collections of pure fry from these niche (Fig. 14).

The position of the dorsal before the ventrals distinguishes the fry from uneconomic minnows of the genus, *Barilius Danio* and *Rasbora* found in the same niche. The smaller barbels, *Barbus (puntius) Sarana* (Hamil) *and Barbus filamentosus* do not occur mixed with the fry of *Barbus dubius* and even if found they develop a dorsal blotch and prominent scales earlier. In *Barbus dubius* there is practically no pigmentation till it is 1 c.m. long. The fry of 1 to 1.5 c.m. show a lateral band against a clear back ground and by 1.4 to 1.5 the characteristic dorsal blotch bent downwards develops. In the field collection however along with *Barbus dubius Barbus hexagonolepis* occurs. Size for size the latter is darker and the blotch is spread equally above and below (Fig. 15).

Discussion.

Barbus dubius is a fish distributed in the upper reaches of the Cauvery and Bhavani in the sub-mountainous area. These areas are akin to the Greyling zone, Barbel Zone (Marcel Huet 1959) of Western European streams. Many of the multi-purpose reservoirs are constructed in these zones and hence the study of the biology of the fish *Barbus dubius* in the new reservoirs is of immediate importance from the point of view of its growth and repopulation. While Barbus dubius has become an established Fishery in Bhavanisagar and Krishnarajasagar its disappearance from Mettur Reservoir is answered by a study of the breeding habits.

1. The fishes grow to a good size in the reservoirs as was recorded from Mettur originally and now from Bhavanisagar. They grow to 250 m.ms. in the I year, to 360 m.m. II year to 440 mms. III year 520 mms. IV year 570 mms. V year 610 mms. VI year, and 670 mm. VII year. The corresponding growth in weight from second year onwards is 455 gms. 975 gms., 1,527 gms., 2,335 gms., 3,017 gms, and 3,505 gms.

2. They feed mainly on the benthic chironomid larvae, fresh water oligochaetes, insects and nymphs at depths from 2 to 10 meters. They also feed on the plankton of the reservoir.

3. The fish breed once in a year extending from October to December. The fecundity spawning and development has been worked from field collections and by artificial stripping.

4. There is a distinct short spawning migration from November onwards towards the top waters of the not very big hill streams. The eggs are laid in shallow gravelly areas by the side of rapids and pools and the fish return to the reservoir after the spawning. Both the upward and return migration have been intercepted by drift nets for analysis.

5. The eggs are heavy with little perivitelline space unlike carps and hence they do not get drifted with the floods. The fry hatch out in large number in the spawning belt and get washed down when they are 3 to 5 cms. long. Thus the reservoir below the spawning belt gets successfully repopulated. In the case of Mettur Reservoir, the Hoganaikal falls connecting the top river becomes a natural barrier during October to December bacause it is insurmountable. The migration was checked which accounted for the disappearance in Mettur. Similarly in Amaravathy Reservoir situated in Coimbatore, the top water is intercepted by the Duvanam falls where oozing breeders congregate in large numbers from December. By February, the gonads get atrophied as the fish are prevented from spawning. The only repopulation in this case is stocking, the top water immediately above with breeders and allowing the fry to get drifted down. There is always an assured chance of repopulation of *Barbus dubius* in all reservoirs with even a small hill stream like top water run where free access to spawners is assured.

6. The fishes are caught in synthetic yarn Rangoon nets and best catches are recorded after the spawning season The nets are laid to advantage in the 5 meters to15 metres belt of the reservoir around the top waters where they congregate after spawning.

7. The conservation programme must aim at completely closing for any type of fishing, the top waters for a distance 7 to 8 miles which are the favourite spawning grounds.

For Commercial fishing in the reservoir, drift net with mesh of 6 cm. fully stretched and above may be allowed. Then the fish three year and below will not be caught and breeder stocks will be maintained to get a fair chance of spawning once.

The fish is recommended for stocking any major reservoir in the sub-mountainous area provided there is a suitable river stretch above with no barrier preventing the upward migration.

Acknowledgements—

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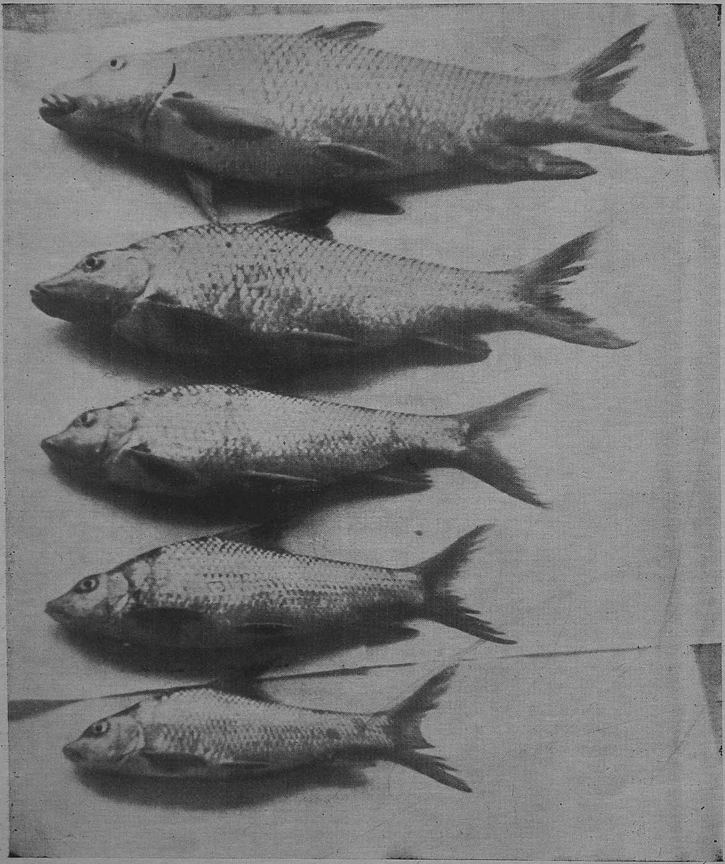


Photo 1—*Barbus dubius*—Five-year classes fishery from Bhavanisagar landing.

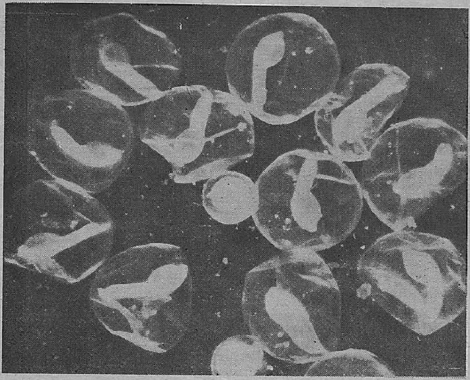


Photo 2—Fertilised egg of *L. Rohita* from induced spawning

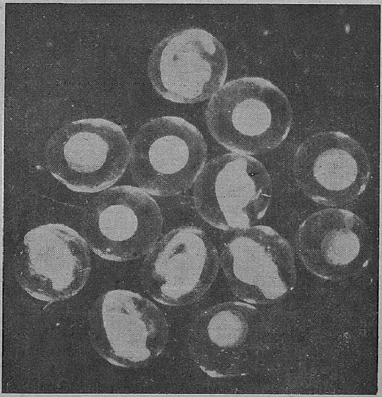


Photo 3—Fertilised egg of *B. dubius* in various stages of development

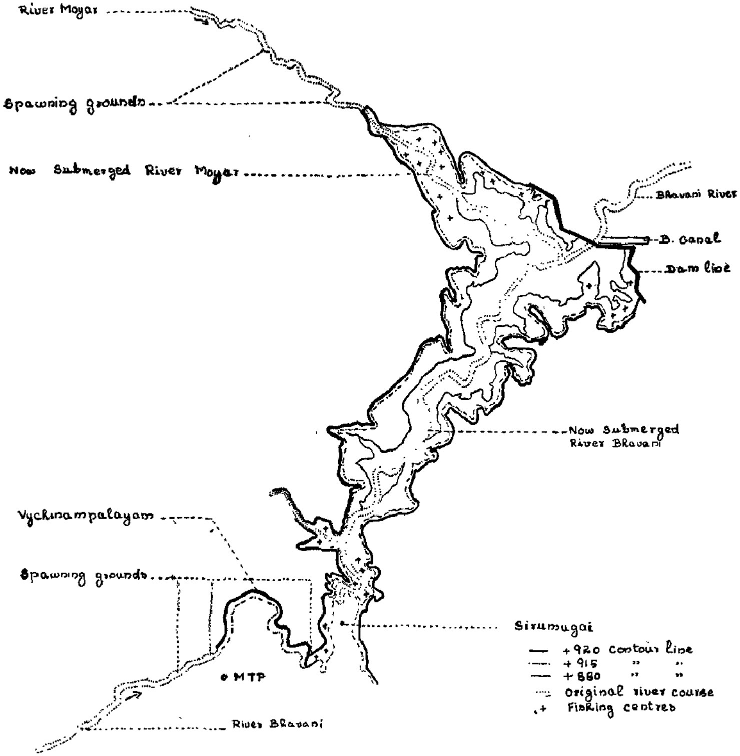


Fig. 1—Bhavani Sagar Reservoir Showing contourline, Fishing centres and Spawning beds of Barbus dubius.

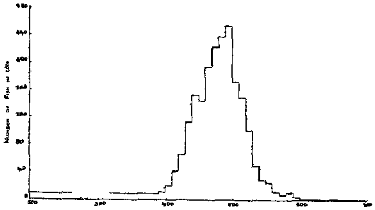


Fig. 2—Total Length m.m.

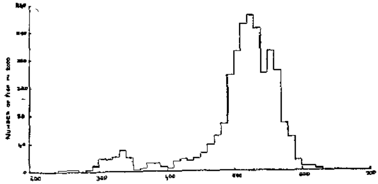


Fig. 3—Total Length m.m.

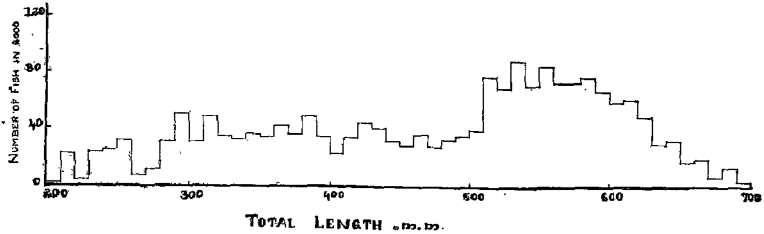
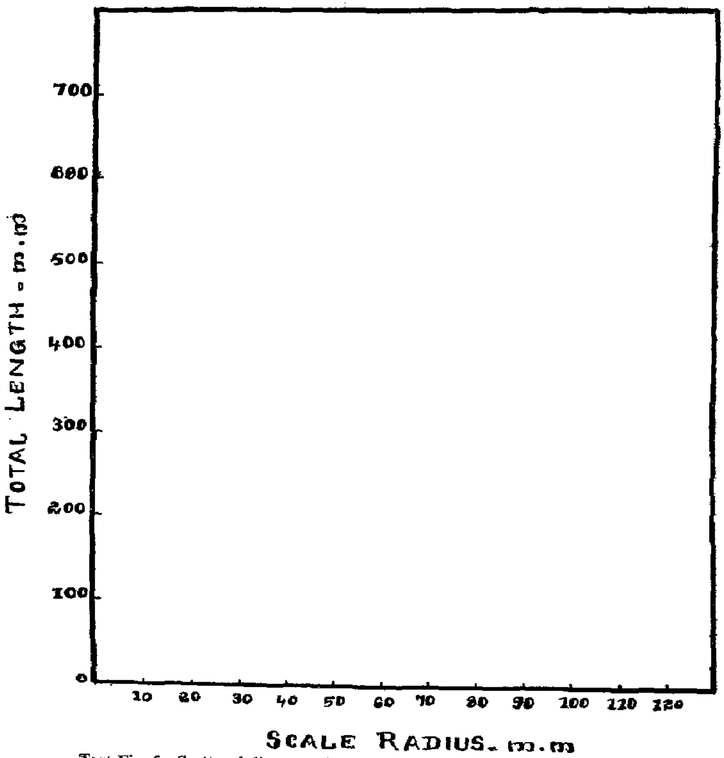


Fig. 4—Total Length m.m.



Text Fig. 5—Scattered diagram of total length and radius of scale in *B. dubious.*

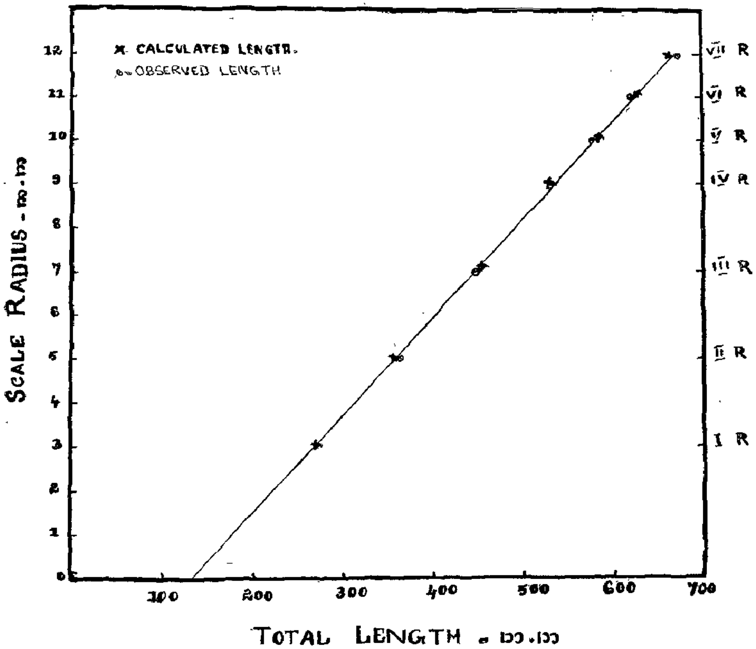


Fig. 6.—Graph representing observed mean length calculated length and the radius of the scale.

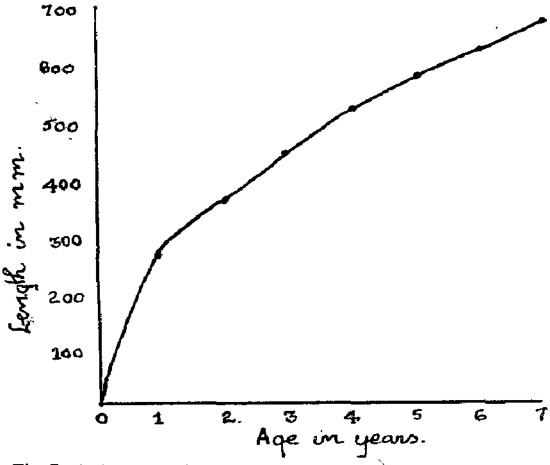


Fig. 7.—Relationship between age in years by scale reading and calculated length.

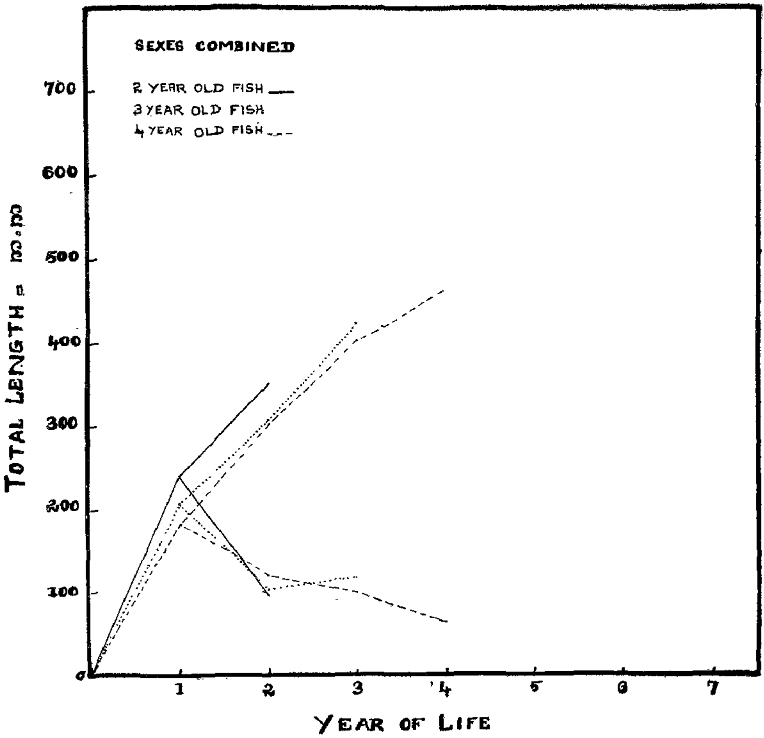


Fig. 7 (a)—Growth in length and increment in *B. dubius* (2nd to 4th year)

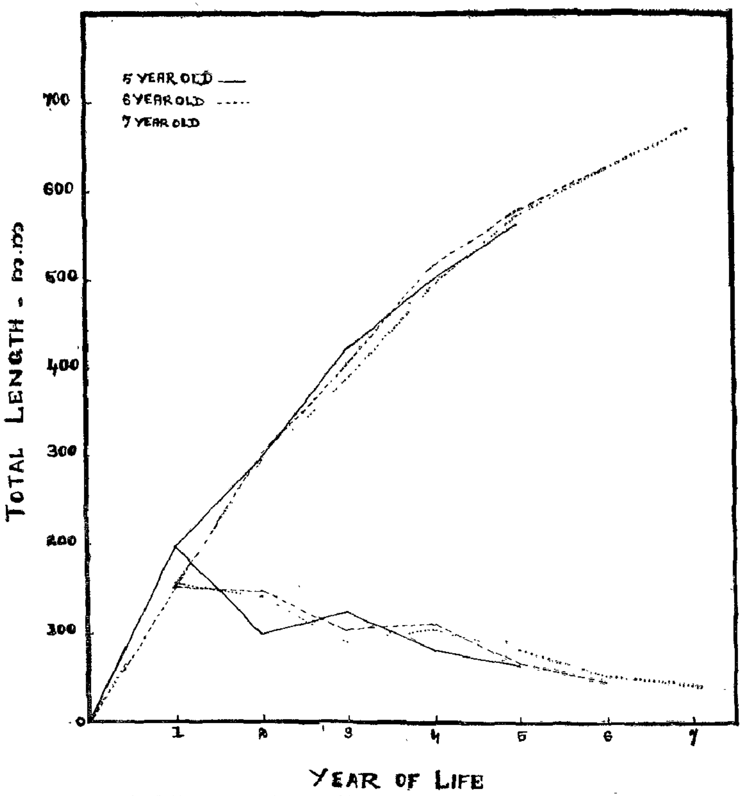


Fig. 7 (b)—Growth in length and increment in *B. dubius* (5th to 7th year).

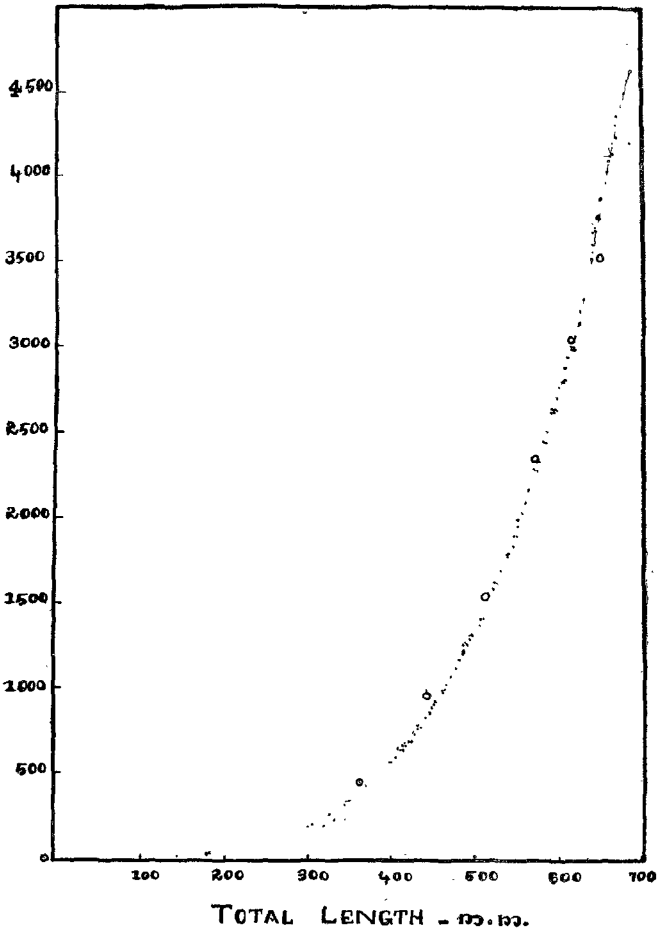


Fig. 8.–Scattered diagram of weight on length in *B. dubius*. (O—denotes calculated weight using the formula W=Cln.)

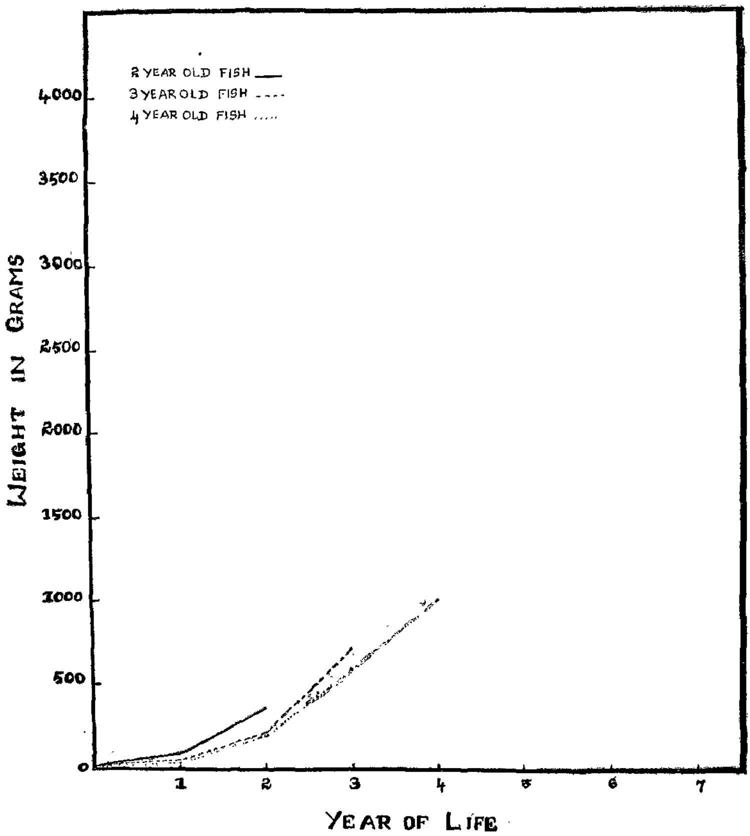


Fig. 9.—Calculated growth in weight at the end of each year of *B. dubius* (2nd, 3rd and 4th year).

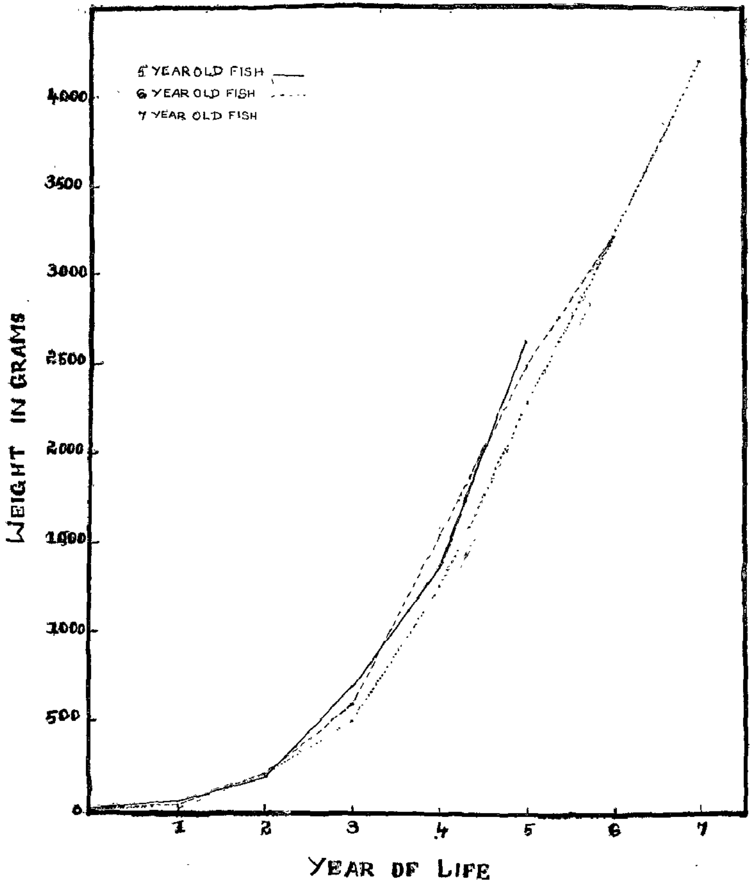


Fig. 10.—Calculated growth in weight at the end of each year (5th, 6th and 7th year) in *B. dubius*.

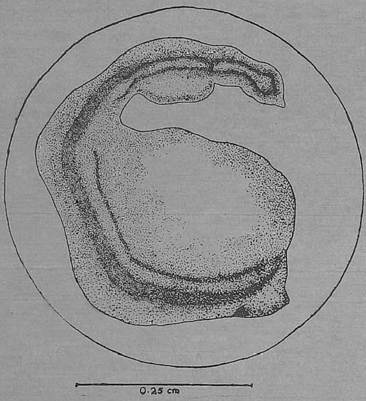


FIG. 11—Fertilized egg of Barbus dubius 18—hours old.

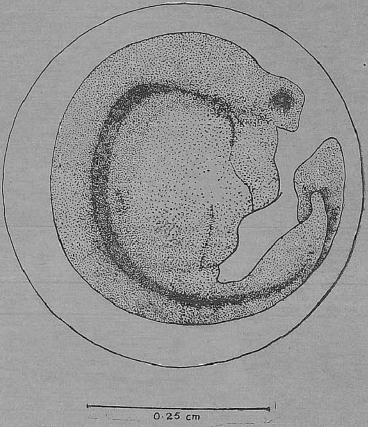


FIG. 12—Fertilized egg of Barbus dubius 36—hours old.

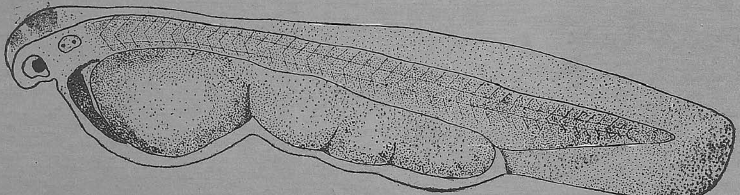


FIG. 13—Larva of Barbus dubius just after hatching [72—hours-old].

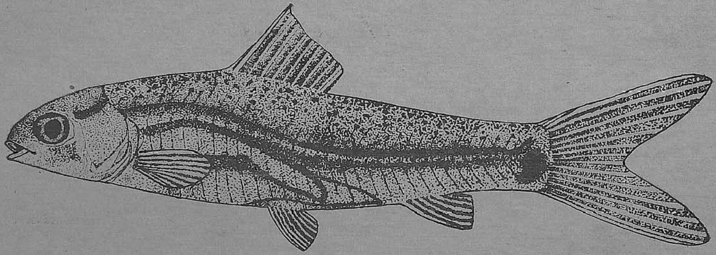


FIG. 14—Barbus dubius fry 2 cms long.

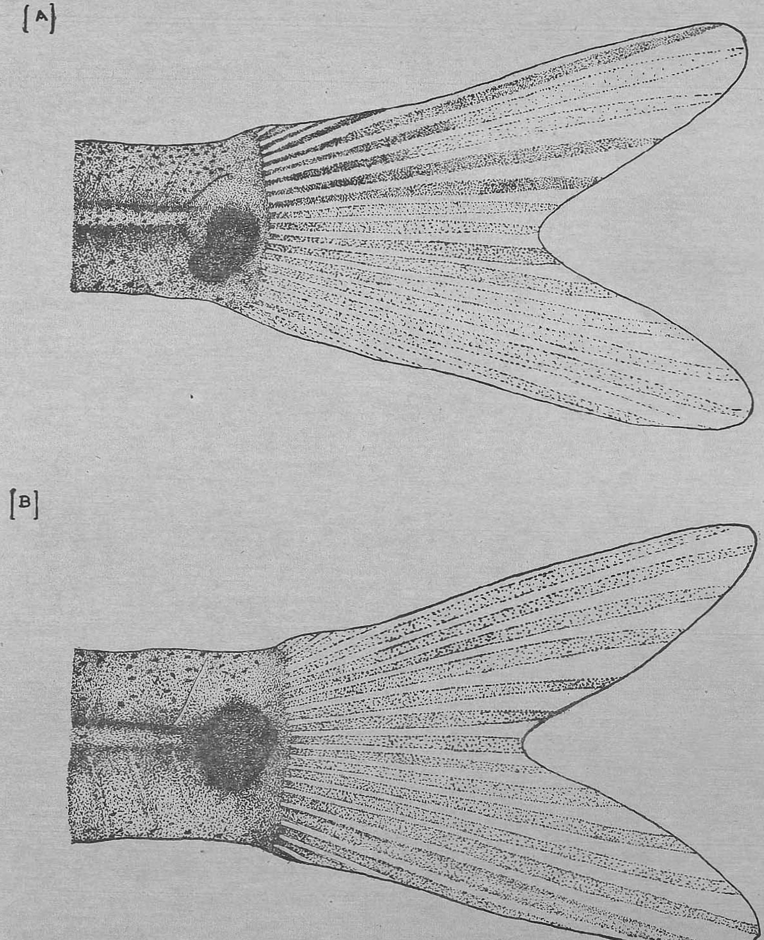


Fig. 15—Caudal peduncle of 0 cms. long fry of [A] Barbus dubius and [B] Barbus hexagonolepis.

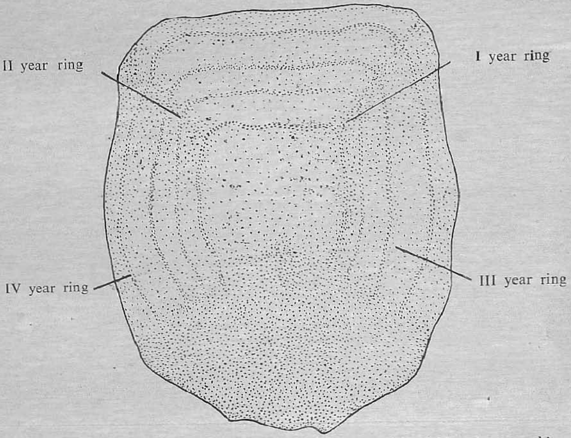
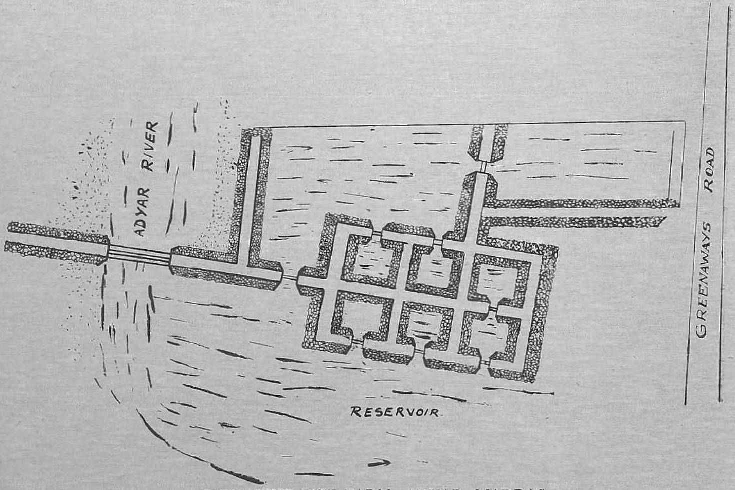


Fig. 16—An×6 camera pucida drawing of a scale of *B. dubius*, 4 years old.



ESTUARINE FISH FARM, ADYAR, MADRAS.

STUDIES ON THE AGE AND GROWTH OF THE KEERIMEEN CHALAI SARDINELLA SIRM

BY

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Introduction.

In the economy of the fishing villages of the East Coast of Madras State, there is probably no fishery of greater importance than that of the Sardines, locally called *Chalai*. Though studies regarding the fisheries and biology of *Sardinella fimbriata* and *S. Gibbosa* have been conducted by workers like Bapat (1955), Chacko (1946, 1949, 1950, 1956 and 1959), Chacko and Palani (1959), Chacko and Rajendran (1956), Devanesan (1932), Devanesan and Chidambaram (1953), Panikkar (1949) and Sekharan (1955), not much attention has been paid to *Sardinella sirm*, except for a few observation by Chacko and collaborators (1956 and 1959) and John (1951). This paper gives an account of the investigations on the age and growth of *Sardinella sirm* which contributes to a valuable fishery in the Gulf of Mannar off Tuticorin. the season extending for about six months from October to March.

Material and Methods.

The specimens of *Sardinella sirm* used in these investigations were collected by the random sampling method from the commercial catches of fish from the off-shore fishing grounds off Tuticorin Coast. The chief gear employed for the capture of these sardines was the *Kola-Valai*, a type of drift net composed of six sections, each of 120 feet length (26 metres) and 40 feet (12 metres) breadth and of half-inch (72 mm.) mesh from knot to knot. Altogether 170 samples totalling 14,500 specimens were collected from January 1957 to March 1961. The specimens were measured at the landing centres itself in the most fresh condition. Specialised methods were not employed for obtaining juveniles and smaller fishes, below 130 mm. size except in 1958 to 1959 season when a *Chalai-Valai* a small meshed drift net was used. Total length of the fish was taken from the tip of the snout to the end of the longest caudal ray.

The minimum and maximum size recorded from the normal commercial catches was 125 mm. and 25 mm. This range was divided into ten millimetre groups and their frequency was represented as in Figures 1, 2, 3, 4, and 5. This showed the percentage distribution of the size supply in the monthly samples. Where the totals were too small to be representative of the population the figures have been left out in the reckoning as having no samples for the purpose of length-frequency studies. Percentages have been tabulated in preference to total numbers in each size-group to facilitate comparison of data for different months as the total differed from month to month. Size sampling and calculations of means were made for the samples individually and then compilations done by monthly totalling. Recalculation of the different values on this basis resulted in the increases of the value of larger samples analysed and in the month-to-month values being more reliably comparable than the sample-to-sample values. Any possible variations in the monthly totals due to uncontrollable sampling errors were also considerably reduced.

Size composition of Commercial Catches.

1. *January to April* 1957.—There were two modes in January, one at 140 mm. and the other at 170 mm. appearing as two separate stocks. In February, there was a new mode at 130 mm. probably representing another stock for the year. The mode at 170 mm. might represent a growth of 30 mm. of the 140 mm group and merging with the 170 mm. group of the previous month that did not show any conspicuous growth. This might be due to rapid growth resulting in the fish spawning towards the end of February. In March there was a mode at 180 mm. denoting a growth of 10 mm. The mode at 210 mm. might probably show spawning growth of the 170 mm. group that either showed a steady growth in February or was not represented during that month. The growth which thus seemed to have occurred in one or two months might coincide with spawning activity from the latter part of February to the end of March. The non-representation of the 130 mm. group in March was due to the increased percentage composition of 150 to 170 mm. groups merging with the total stock indicating growth of the fish. In April, the season came to a close with landings on a few days only and as such the mode at 180 mm. represented the same stock met within the previous month, while the 210 mm. group might have been fished out. Assuming that spawning occurred in the latter half of the season, there might have been probably a spawning in the early half of the season. This was confirmed by observations made during the succeeding seasons. Likewise it is probable that there was a spawning in each of the three months to result in four spawnings in one year, two met with in the fishery season along Tuticorin Coast and the other two in the off-season.

2. 1957–58 *Season*.—The fish appeared in September 1957, and the fishery extended to March 1958. In September, there had been two modes on at 170 mm. that formed the major fishery and the other at 210 mm. The former was evidently the main stock for that year's fishery and from the recruits from the spawning in the early half of 1956–57 season. The latter group might be an older group of the previous year. In October, the second peak

at 210 mm. was no longer visible resulting in a unimodal curve with a peak at 180 mm. Assuming that the population had been the same throughout the forward movement of the mode by 10 mm. indicated clearly the growth that occurred during that period. In the next month, there were three modes. One was at 170 mm. denoting fresh entrants into the fishery. These might be the off-springs of the second spawning that occurred in February 1957 in the latter half of the 1956–57 season. This also showed that more than one spawning occur in one season confirming the average of one spawn in three months. The second mode is at 190 mm. due to the 10 mm. growth of 180 mm. group. The third mode at 220 mm. illustrating the growth by 10 mm. of the 210 mm. group of September. The non-representation of these in October might be due to the lesser landings and fewer number of samples analysed. In December, which was the peak season for the fishery, the three modes had advanced by a few millimetres indicating the growth of all the three size-groups. The 170 mm. group showed an advancement by 10 mm. represented by the mode at 180 mm. The 190 mm. group has grown to 220 mm. group. The 220 group showed a growth of 30 mm. 20 mm. reaching 240 mm. This greater advancement was indicative of the spawning of the 190 mm. and 220 mm. group. This was the first spawn of the season. During January 1958, the 24 mm. mode of December had disappeared. The 180 mm. group had advanced by 10 mm. and represented at 190 mm. constituting the main fishery, while the 220 mm. group had not attained much conspicuous growth. In February, the mode at 190 mm. was predominantly indicating the main stock of the fishery which in addition to the mode might probably be fresh recruitment, indicative of two other spawnings that might have occurred during the off-season. The 220 mm. group was not to be observed, having been fished out, in all probability. The mode at 210 mm. might represent rapid growth of the 190 mm. group of January indicating the second spawning during the season. In March, a new mode was seen at 180 mm. which might probably be the spawning growth of the 140 mm. group. It can be safely presumed that the first maturation of the fish, took place nearly at the 140 mm. size. Hence, the age of the fish of 140 mm. was one year. Growth was not conspicuous with the 190 mm. group also, that had not attained any mode, but it could be understood that growth had taken place, from the greater percentage of the 190 mm. and 220 mm. groups, in the previous month. The 210 mm. mode showed the same crisis with addition in the bigger size-groups, denoting inconspicuous but steady growth.

As confirmed, it was seen that each three months enclosed one spawning of the fish as such, a season consisting of six month's showed two spawnings. There might be two more spawnings for the fish species during the other half year which is the off-season. Its fishing at Tuticorin as spawning occurred in November and February during the fishing season at Tuticorin, was suggestive that the third and fourth spawning might be in May and in August during the off-season when the fish had moved into deeper waters. With this in consideration, it was clear that fresh recruitment with the commercial catches occurred in September 1957 (170 mm.), November 1957 (170mm.) and in February 1958 (140 mm. and 190 mm.). These four stocks might be out of the four spawnings of the previous year. As could easily be recognised, the 170 mm. set of September 1957 might be of the May 1956 spawning. Likewise, the 170 mm. set of November 1957, the 190 mm. and 140 mm. of February 1958 might be of the spawning in August 1956, November 1956 and February 1957. On the whole in the 1957–58 season, the 170 mm. group of September 1957 had grown over 50 mm. to reach 220 mm. in December. The 170 mm. set of November 1957 showed advancement of 40 mm. reaching 210 mm. in February 1958. The 210 mm. groups of November 1957 showed an increment of 30 mm. to reach the 240 mm. maximum size in December 1957. The average growth rate is thus about 12 mm. in a month. But this increased to 20—30 during the month immediately preceding spawning actually.

3. 1958–59 *Season*.—The fishery commenced only in November, when three modes at 100 mm., 140 mm. and 170 mm. were seen to occur. The 170 mm. size-group comprised the main bulk of the fishery and probably was from the spawning of August 1957. Correspondingly, the 140 mm. and 100 mm. groups might be of November 1957 and February 1958 spawnings. It was interesting to find that the intermediate size-groups of 110 mm. and 120 mm. were not at all represented in the catches. During December, there were again 4 modes. The 110 mm. mode indicated a growth of 10 mm. of the 100 mm. fish. The mode at 130 mm. might be a fresh group, probably of the November-December 1957 spawning that was not represented in the previous month. The 160 mm. mode might be due to the 20 mm. growth of the 140 mm. group and similarly the 190 mm. mode showing the growth of 20 mm. of the 170 mm. groups. The growth increment of 20 mm. put in by the 140 mm. and 170 mm. might forecast a spawning at this time which is the assessed first spawning period of the season. In January, there was a new mode at 90 mm. of juveniles. These along with the 110 mm. to 130 mm. fish were collected separately by means of '*Chala Valai*' of nearly 8 mm. knot to knot. This 90 mm. group might probably be a population of the August 1958 spawning having completed only six months. The mode at 120 mm. represented growth of 10 mm. of the 110 mm. group of December. There was also a mode at 170 mm. which might denote a growth of 10 mm. of the 160 mm. group. The 130 mm. group was not represented and this might be due to a probable migratory move of some groups of the year classes to deeper waters, when in January the fishery came to a drop for a few days. In February, the main bulk of the commercial landings comprised only 170 mm. sized fish. This might be the same group of January growing steadily without showing any conspicuous mode. The growth of the 130 mm. group of December was not likewise conspicuous perhaps due to its migration, to be non-represented as in the last month. However, growth curve below 170 mm. indicated more representatives of 150 and 160 mm. sizes. This might prove the rapid growth of the 130 mm. group and its merger with the bulk of 170 mm. group.

As the fishery for this season was poor, enough samples for length-frequency studies could not be had in March

However, for the whole season, there were three size-groups. The 100 mm. group of November showed a growth of 20 mm. by January, a period of about two months, showing steady growth before completion of one year and attainment of maturity. The 130 mm. group of December showed a growth of 40 mm. to reach 170 mm. in February, a period of three months. The 140 mm. group had put in a growth increment of 30 mm. in three months.

4. 1959–60 *Season*.—During this season sufficient data on the studies could not be collected due to administrative reasons and lack of personnel and consequently the studies could not be carried out.

5. 1960–61 Season.—The fishery commenced in October 1960, with the 180 mm. and 220 mm. size-groups. In the next month of November two modes occurred one at 180 mm. and another at 150 mm. representing the stocks of the August and November 1959 spawning. The 210 mm. mode obviously showed the rapid growth of 180 mm. group by 30 mm. to forecast the first spawning of the season, while the 220 mm. group of October was not represented. This denoted that the older group had been fished out. In December, the mode at 180 mm. stood steady, while the 150 mm. group that might have attained maturity and a growth of 30 mm. merged with the 180 mm. group. The bigger groups of 20 mm. and above were not represented. During January, a new mode was seen at 170 mm. which might probably be the stock of the November 1959 spawning. There was also a mode at 210 mm., indicating growth of the 180 mm. group by 30 mm. This intense growth obviously signified an imminent spawning. In the next two months, the new set of 170 mm. group showed a steady growth of 10 mm. so as to form the mainstay of the fishery towards the close of the season. The 210 mm. group showed an advancement of 10 mm. to reach a size of 220 mm. The non-representation of the other groups might be due to the fewer numbers in the random samples that could be obtained.

In this season, the 180 mm. group only predominated but the 150 mm. group of November showed a growth increment of 30 mm. in two months up to December 1960. Further growth was not conspicuous to produce any mode, but growth was noted by the larger percentages of bigger groups above 180 mm. extending up to 230 mm. The 180 mm. group had put in a growth of 40 mm. reaching 220 mm. size in three months. The speedy advancement in size of the 150 mm. and 180 mm. groups in November and January respectively indicate spawning and it was evident also that there were two spawnings in the fishery season of six months.

Growth rate.

The studies on the various size-groups, though showing seasonal fluctuations throw considerable light on the growth of the fish. In the 1956–57 half-season, the 140 mm. group appearing in January 1957 showed a growth rate of 40 mm. in three months. More rapid growth occurred in February 1957. The 170 mm. group of January 1957 had grown over 40 mm. in three months. Spawning growth occurred in February-March.

The 1957–58 season proved the growth of 140 mm., 170 mm. and 210 mm. groups. The 140 mm. group appearing in February reached 180 mm. in March and their intense growth denoting spawning might also show the first maturity of the fish. One group of 170 mm. appearing in September had put in a growth of 50 mm. within December in four months, indicating spawning growth in December. Another set of 170 mm. appearing in November had grown through 40 mm. to reach 210 mm. in February a period of four months. Greater growth denoting spawning occurred in February. The group had stood steady for the first two months. The 210 mm. group appearing in September had a growth increment of 30 mm. to reach 240 mm. in December, when intense growth is also seen and as such December and March might be considered as the two spawning months for the season.

In 1958–59 season, 100 mm. group appearing in November over 120 mm. in two months by January. The 130 mm. group appearing in December was not represented conspicuously in the other months, and might be said to grow steadily and slowly, being a juvenile group. The 140 mm. group appearing in November showed a sharp growth in December and reached 170 mm. in January. This growth rate was very satisfactory.

During the 1960–61 season, the 150 mm. entering in November showed a sudden growth of 30 mm. in December and thereafter did not show any conspicuous mode. The 180 mm. group of October advanced rapidly in November to reach 210 mm., growth increment being 30 mm. in two months. Another set of 180 mm. entering into the fishery in November showed a steady growth till December and grew up suddenly by 30 mm. from January to February to reach 220 mm. The growth was 40 mm. in four months. Thus November and February appeared to be the two spawning months for this season.

Inference and Conclusions.

From the foregoing studies the following inference and conclusions are made :—

(1) *Sardinella Sirm* attains maturity when 140–150 mm. in total length.

(2) The growth in length is steady till 210 mm. when the fish spawns for the second time.

(3) The fish reaches senescence and maximum size of 240–250 mm. in nearly $1\frac{1}{2}$ years.

(4) Bigger specimens up to 300 mm. in length are rarely seen during the off-season.

(5) The fishery season from October to March is short and is about one-fourth of the probable life span of the fish.

(6) As these occur in more than one fishery season within the full life period, there is a period of successive spawning.

(7) There is one spawning period every three months in November-December and February-March during the fishery period and in May-June and August-September during the off-season.

(8) The main spawning periods in the life of the fish are when 140–150 mm., 170–180 mm. and 120–210 mm. in length.

(9) Juveniles below 140 mm. in length and older ones above 250 mm. in length are not obtained in the commercial catches.

(10) Rate of growth averages 10–12 mm. a month.

(11) There is a rapid growth of about 20–30 mm. in the month prior to spawning.

Acknowledgment.

I am indebted to Sri P. I. Chacko, Assistant Director of Fisheries (Information and Marine Biology), for suggesting the problem and for the guidance and encouragement given during the course of the investigations.

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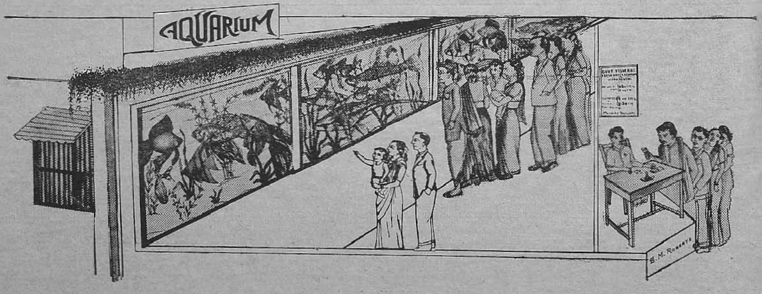

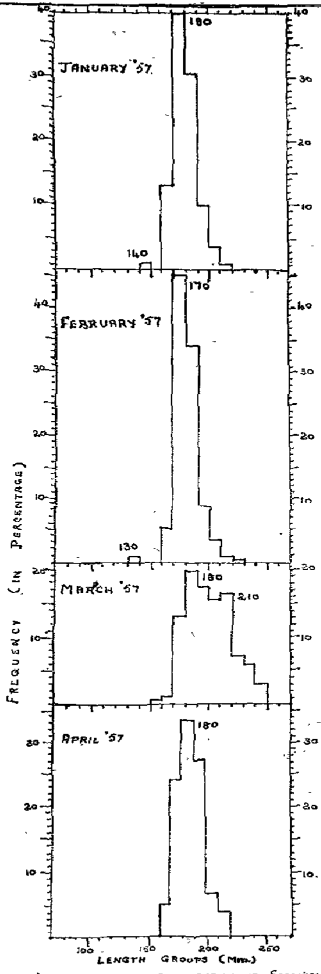

Fig 1. Monthly Length frequency distribution of *Sardinella sirm* during 1956-57.

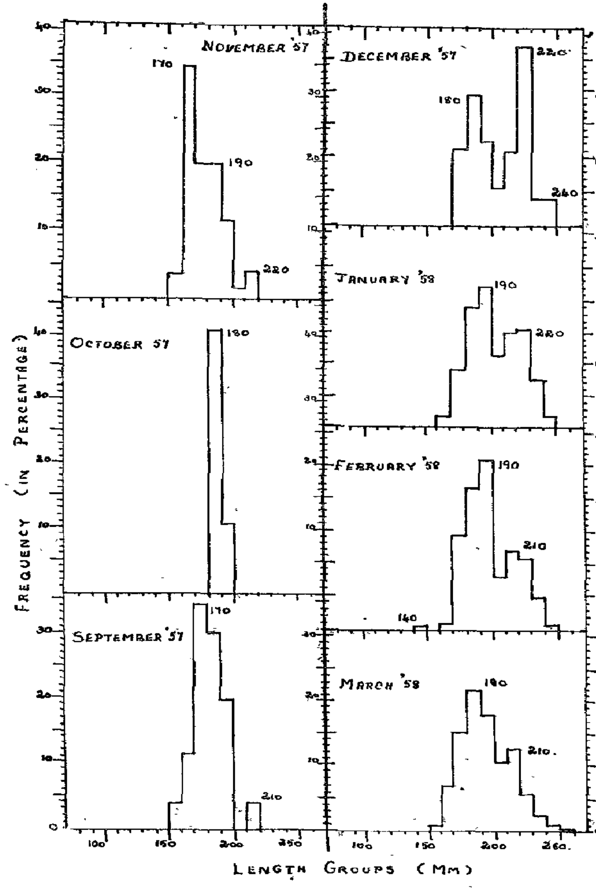

FIG 2. MONTHLY LENGTH FREQUENCY DISTRIBUTION OF SARDINELLA SIRM DURING 1957-'58

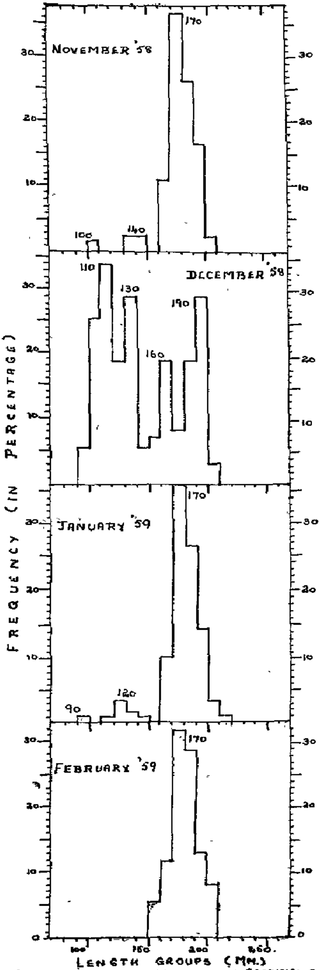

Fig. 3. Monthly Length frequency distribution of Sardinella sirm during 1958-59.

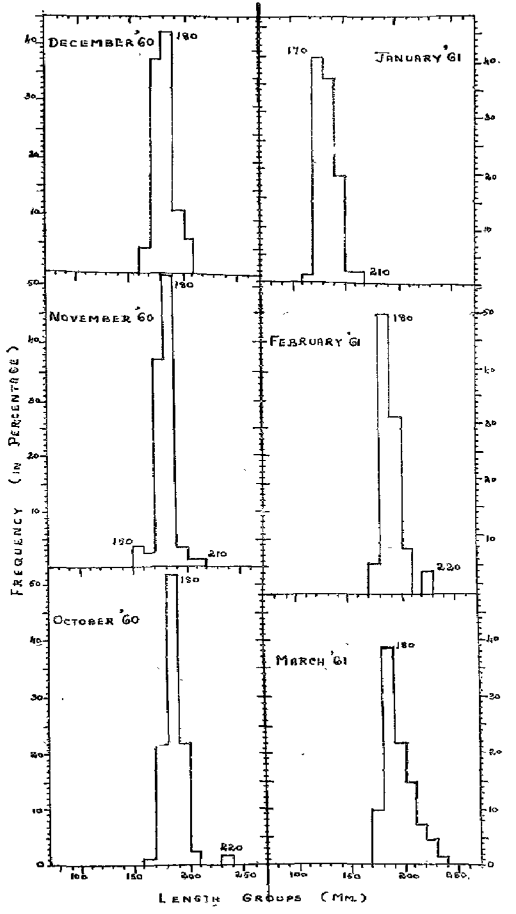

Fig 4 Monthly length frequency distribution of Sardinella sirm during 1960-'61

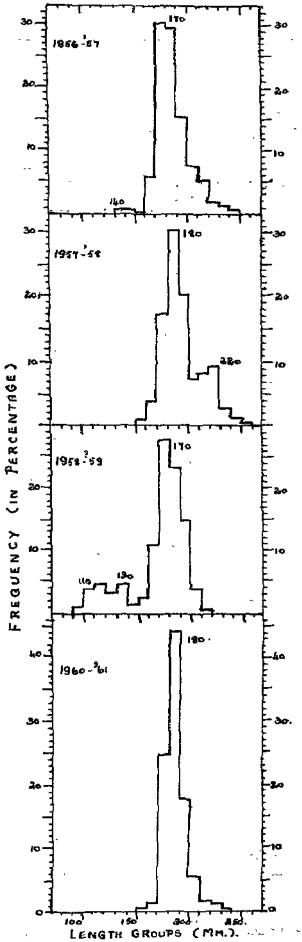

FIG. 5. ANNUAL LENGTH FREQUENCY DISTRIBUTION OF SARDINELLA SIRM DURING 1956-57, 57-58, 58-59 AND 1960-61.

FOOD AND FEEDING HABITS OF FISHES OF THE PERIYAR LAKE

BY

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Introduction.

The Periyar Reservoir constructed across the Periyar River in about 1890, utilises a portion of the waters of this river for irrigating lands in the Madurai, Melur and Nilakottai taluks of the Madurai district.

The 150-feet high dam has created an extensive lake. Its water are diverted eastwards through a mile long tunnel and are led into Suriiyar, which again joins the Vaigai river flowing through Madura and Ramanathapuram districts before its outfall in the Bay of Bengal. The Periyar waters irrigate 143,000 acres of land. The lake is surrounded by thick and evergreen forests on all sides and is replete with wild game. It has been declared a game sanctuary.

A survey of the fish fauna of the Periyar lake was conducted in March and July 1954. Collections were made from different sections of the lake and the inflowing streams by employing cast nets and velon-screen, dragnets in shallow areas and kondivalai and Rangoon nets in the deeper portions.

List of fishes.—The following kinds of fish were collected from the lake during the survey :—

(1) *Barbus curmuca*
(2) *Barbus micropogon*
(3) *Barbus tor*
(4) *Callichrous pabda*
(5) *Discognathus lampta*
(6) *Saccobranchus fossilis*
(7) *Ambassis ranga*
(8) *Barbus aurelius*
(9) *Barbus melanampyx*
(10) *Barilius bakeri*
(11) *Botia historensis*
(12) *Etroplus maculatus*
(13) *Aplocheilus lineatus*
(14) *Lepidocephalichthys thermalis*
(15) *Macropodus cupanus* and
(16) *Rasbora daniconius*

Food and Feeding Habits.—This was investigated as detailed below :—

(1) *Barbus curmuca*—

Size range	16·5—37·5 cms.
Length of gut	26·5—74 cms.
Number of guts examined	17
Number of empty guts ..	1
weight of gut contents ..	4–10 gms.

Gut analysis—

Rotifers, *Cypris*, Daphnids, *Navicula*, filamentous algae, macro vegetation, Graminae seeds, blades of grass bamboo leaf bits and seeds.

The guts are nearly double the length of the fishes. Of the seven guts examined, three showed, zoo-plankton. The other four showed grass blades, Graminae seeds, bamboo leaves and seeds which show that, *B. curmuca* feeds mostly on macro vegetation like grass, bamboo leaves and fruits. They were also reported to be found feeding along the banks of the reservoir on grass in shallow waters.

(2) *Barbus micropogon*—

Size range	34–35 cm.
Number of guts examined	4
Length of stomach ..	16·5–45 cm.
Weight of gut contents ..	50–100 gm.
Vol. of gut contents ..	48–95 cc.

Gut analysis—

Large black ants.	Jumblum nuts each of 19 grammes weight +1·1 cc. vol.
Beetles ;	Caesalpinea leaves.
Wings of aquatic insects ;	Bamboo leaves.
Rotifers ;	other Macro vegetation.
Cyclops ,	Germinated seeds.

Feeding habits.—The stomach is well differentiated from the gut and is nearly half the length of that of the gut and in 2–4 cms. in diameter. All the guts examined showed 50 per cent of large black ants, water beetles and hundreds of wings of aquatic insect. The number of wings present in different guts ranged from 347 to 700. This shows that these fishes are mainly insectivorous in habit.

In addition to this, nearly 50 per cent of large quantities of macro vegetation like Caesalpinea leaves, bamboo leaves, blades of grass and large jumblum nuts have been found in the gut. In one stomach, 452 jumblum nuts showing a volume of 50·4 cc. were present along with the other macro vegetation, ants and beetles. This shows that this fish feeds on vegetation and fruits also.

(3) *Barbustor*—

Size length	33·7—43·5 cm..
Number of fishes	6
Length of guts	156–86·5 cm.
Length of stomach ..	28—46·5 cm.
Number of emptv guts ..	2
Weight of gut contents ..	4–5 gm.
Vol. of gut contents ..	1–5·5 cc.

Gut analysis—

Black ants, beetles, and insect appendages.

Feeding habits.—This seems to be definitely a purely insectivorus fish. It seems to feed on aquatic insects and black ants. The intestinal region is much narrower than in B. micropogon and showed only digested matter.

(4) *Callichrous pabda*—

Size range	8·1–8·9 cm.
Number of fishes	3
Length of guts	10–11 cm.
Length of stomach ..	1–1·5 cm.
Number of empty gut ..	1

Gut analysis—

Paramoecium	*Ulothrix*
Rotifers	*Spirogyra*
Rasbora	

Feeding habits.—The guts are longer than the length of the fish. The stomach is a short pear-shaped one with highly muscular walls which are produced into longitudinal folds. The oesophagus and intestines are very narrow. Of the three fish examined, the gut in one w as empty. Of the other two, one showed ciliates, rotifers and green algae The other one showed a just-swallowed complete specimen of a 4 cm. long *Rasbora daniconius*. It was tightly packed in the one cm. long muscular stomach. *Callichrous pabda* is a carnivorous fi.h which can eat up a smaller fish nearly half its own length.

(5) *Discognathus lampta*—

Number of fishes examined.	5
Size range	11·1–14 cm.
Length of guts	121—155 cm.
Stomach	Not differentiated.
Number of empty guts ..	4

Gut analysis—

One beetle ; Hormidium ; Blue green algae.

Feeding habits.—Nothing could be definitely said about the feeding habits of *Discognathus lampta* till more specimens are examined. Out of the six guts examined four were empty. The only gut showed beetle and blue green algae. It is possible that this fish feeds on insects and plankton. The gut is uniformly slender, narrow and very compactly and spirally coiled. Stomach is not differentiated at all.

(6) *Saccobranchus fossilis*—

Size range	22—22·75 cm.
Number of fishes examined	6
Length of guts	6—17cm.
Length of stomach ..	1 cm. (average).

Stomach analysis—

Chironomid worms ; *Cyclops*.
Insects heads 4—5 ; Protozoans (*Difflugia and Arcella*).
Insect parts ;
Culex larvae—2 ; Phytoplankton (*Closterium; Fragillaria and Phormidium*).
Insect larvae 8—10 ; Scales of fish 175
Shrimp 1–2 ; Fig seeds.
Rotifers Sand grains.
Gastropods (*Limnea* 50 *Planorbis* 2).

Daphnids ;

Feeding habits.—In the six guts examined, 90 per cent of their contents were insect parts, water insects, gastropods and scales and 10 per cent of sand grains. In one gut 50 *Limnea* and two Planktonic organisms were found. In another, shrimp, water insects, *Culex* larvae and other insect larvae were found. In another daphnids, *cyclops*, rotifers and phyto plankton, 175 scales of different sizes were found. This goes to confirm that in addition to being an insect and gastropod eater, this fish feeds on other smaller fishes. Being a bottom feeder this fish also perhaps feeds om scales of dead fish.

(7) *Ambassis ranga*—

Number of fishes examined.	3
Size range	6·5—8 cms.
Length of gut	1·3—2·3 cm.
Length of stomach	0·3—0·4 cm.
Weight of gut contents ..	Very negligible.
Number of empty guts ..	2

Gut analysis—

Camptocanthus 2 ; copepods 3 ; *Diaphanosoma* 3 ; *Cypris* 2 ; Daphnids 2 ;

Feeding habits.—This is supposed to be a cyclopscidal fish. It seems to feed on zoo plankton mainly and copepods whenever available.

(8) *Barbus aurelius*—

Number of fishes examined	4
Size range	6·3—7·4 cm.
Number of empty guts ..	2

Gut analysis—

Euglena ; copepod parts ; *Cypris* ; Daphnids ; Rotifers ; Insect appendages.

Feeding habits.—Of the two guts examined, one presented 50 per cent of *Euglena* and 50 per cent of other Zoo plankton. The other gut showed 75 per cent of zooplankton and 25 per cent *Euglena*. This is a plankton feeder.

(9) *Barbus melanampyx*—

Number of fishes examined 9

Size range .. .. .. 2·1–5·6 cm.

Number of empty guts .. 5

Gut analysis—

Insect appendages; insect heads; beetles; algal filaments.

Feeding habits.—Very little is so far known regarding the feeding habits of this fish. Of the four guts examined, all showed beetles and other insect appendages and parts. One of the guts showed a few parts of algal filaments. Two of the guts showed fine sand grains. This fish seems to feed on aquatic insects mostly.

(10) *Barilius bakeri*—

Number of fishes examined. 9

Size range .. .. .. 3·6 cm.

Length of guts .. .. 4·5—8·5 cm.

Number of empty guts .. 3

Gut analysis—

Rotifers; gastropods; insect parts; shrimps; algal filaments.

Feeding habits.—Of the five guts examined, all showed insect parts, and rotifers; two showed gastropods and shrimps and one showed insect parts only and another showed algal filaments in addition to rotifers and insect parts. Evidently this is an insect feeder, feeding on insects and rotifers. Occasionally it may feed on algae also.

(11) *Botia historensis*—

Number of fishes examined. 6

Size range .. .. .. 3—6·1 cm.

Number of empty guts .. 5

Length of gut .. .. 2·6 cm.

Length of stomach .. ·5 cm.

Gut analysis—

Insect parts; insect appendages; rotifers; grubs of beetles.

Feeding habits.—This is a purely carnivorous fish. The only gut with food, was full of insect parts, beetle grubs and rotifers. This fish feeds on insect larvae and rotifers

(12) *Etroplus maculatus*—

Number of fishes examined. 6

Size range .. .. .. 4·1—7·5 cm.

Length of guts .. .. 3·1—11·2 cm.

Number of empty guts .. 2

Gut analysis—

Insect parts, *Cyclops*; Rotifers; *Cypris*: Daphnids; *Ulothrix*; *Spirogyra*; *Navicula*; *Fragillaria*;

Feeding habits.—Of the four guts examined one showed insect parts only, three showed *Spirogyra Ulothrix* and other green algae. One showed *Cyclops*, rotifers, *Cypris*, *Diaphanosoma* and, etc., and two showed *Navicula* and *Fragillaria* in large numbers. Though this is supposed o be a cyclopcidal fish, it feeds on other zoo plankton and algae also.

(13) *Aplocheilus lineatus*.—Only two specimens were collected. They were 38 and 40 mm. long. Their guts were empty. Hence nothing could be observed regarding their food or feeding habits from this area.

(14) *Lepidocephalichthys thermalis*—

Number of fish collected .. 3

Size range .. .. .. 3·9—5·6 cm.

Length of guts .. .. 1·3—2 cm.

Number of empty guts .. 3

Nothing could be said about feeding habits as all the guts were empty.

(15) *Macropodus cupanus*—

Number of fish examined. 3

Gut analysis—

Insect larvae; *Euglena*.

Closterium; *Fragillaria*.

Spirogyra; *Oscillatoria*

Feeding habits.—All the three guts showed *Euglena*, green algae, diatoms and desmids. Two of the three guts showed insect larvae. This fish is supposed to be a good larvicidal fish. It can feed on algae and phytoplankton also.

(16) *Rasbora daniconius*—

Number of fishes examined. 3

Size range .. .. .. 7·2—7·7 cm.

Number of empty guts .. 1

Gut contents—

Rotifers; Nauplius larvae; Algae; *Spirogyra*; *Fragillaria*.

Feeding habits.—Even the two guts examined were not full. This fish apparently had fed on algae, rotifers and other phyto plankton. This is supposed to be an insectivorous fish in hill streams.

Fish Parasites.—Trematode and nematode parasites were collected from the intestine of *Barbus tor* and *B. micropogon*. A few nematodes were also collected from the body cavity of *B. melanampyx*. These are being studied and described separately.

Conclusions.—Sixteen species of fishes were collected from the Periyar Lake and were studied for their food and feeding habits.

UTILITY OF CHELA CLUPEOIDES AS A CYCLOPSCIDAL FISH IN STEP-WELLS

BY.

SRIMATHI J. G. ABRAHAM, PUBLIC HEALTH FISH OFFICER, CHETPUT, MADRAS.

Control of water-borne diseases utilising larvicidal and cyclopscidal fishes has been advocated by many. Simply because under controlled conditions, certain species are avaricious eaters of insect larvae, cyclops, daphnids, etc., it does not indicate the same preference in natural waters where the carriers of water-borne diseases live and multiply in relation to other environmental conditions. It is therefore important to assess precisely the role played by larvicidal fishes in controlling the carriers in natural conditions.

There is no doubt that the best method is the use of chemicals which destroy all the planktonic organisms. However, in districts like South Arcot, there are a number of deep step-wells which are the usual and popular sources of drinking water. Protection of these step-wells from human infection or constant chlorination is not always possible. In these circumstances it will be useful to have complete information on the utility of individual species as live controllers of *Cyclops*.

Since they could be effectively controlled and fished easily, two step-wells in Alampoondi village were selected for the experiment. One of the wells was used as control and the other was stocked with *Chela Clupeoides*. Before the commencement of the experiments both the wells were cholorinated heavily to kill all life, especially plankton.

On 31st March 1957, 250 *chela clupeoides* were released into one of the wells. The villagers were instructed not to introduce murrels or any other fishes into the wells and not to catch experimental fishes. Monthly visits were made and dips of plankton were taken each time in the morning hours of 8 a.m. The dip net employed was similar to the type used by the public Health Department. This net can hold *nearly 1 6 litres of water per dip*. In all *months*, except April nearly a dozen *chela* were caught from the well by using a cast net and an equivalent number of *Chela* was introduced into it tokeep the total population constant. The guts of the captured *Chela* were examined and the number of *cyclops* and other organisms present were counted.

The data in Statement I show the actual number of early or larval crustaceans, *cyclops* and other crustaceans present in monthly dips. Part of the data for the first fortnight, every month was taken from the dip collection made by Gingee Health Inspector. Average of I and II fortnight dips were calculated. As there is usually a great percentage of mortality from larval stage to adult cyclops. the larval stages have been included under larval crustaceans and other crustaceans *Diaptomus* is indicated within brackets.

In the experimental well there is a definite reduction of *cyclops* and other crustaceans since May. In the control step well, density of cyclops is maximum in June and of daphnids in May and June. Again in November, *Cyclops* density is rather high, while control water shows only 85 (3) cyclops and 37 daphnids. When they occur in hundreds in control water only 55 *cyclops* occur in experimental water and in September, December and February, the experimental water shows less than 10 *cyclops*, being even as low as six in September, Hence, there is a definite reduction of *cyclops* in experimental waters. But *Chela* feeds also on daphnids in large numbers, if available.

From Statement II, the following points are evident. Even under normal conditions *cyclops* density is low in December and January while it is high in May and June, the maximum being in June. The low density of *cyclops* is perhaps due to loss of water which is baled out for irrigation and due to the excess of water during monsoon.

A total of 110 *Chela* have been collected with cast nets during the period of twelve months and examined. Fifty seven of the fishes showed adult *cyclops* at the rate ranging from 6 to 260 per gut. Ten guts showed appendages of *cyclops* up to 1,750 per gut. Thirteen of the guts were empty. The other 28 guts showed insets appendages and mosquito pupae up to 10 per gut. Besides, *Spirogyra* filaments, *cypris* shells and daphnids, were noted in very small numbers. The guts of *Chela* which contained *cyclops* also showed daphnids to a maximum of 7,330 in a gut. Twenty-five *Chela* showed daphnids, ranging from 120 to 7,330 per gut in addition to *cyclops* larvae, *cypris*, etc. On the whole only 23 per cent of *Chela* examined showed daphnids in large numbers.

Conclusion—

(1) *Chela* definitely checks *cyclops* population in large step-wells and hence prevents *Dracunculus* infection to some extent.

(2) *Chela* also feeds on daphnids, other insects and organisms. But 71 per cent of them feed on *cyclops* predominately.

(3) As mosquito larvae and pupae were found in the guts of *chela*, it can be used for anti-malaria stocking purposes also.

(4) Chlorination cannot be compared with *Chela* introduction in any water-piece as it is very costly and involves more labour and recurring expenditure. In spite of the cost and labour, 10 days after chlorination, plankton can be found in profusion. Hence, chlorination is effective only temporarily.

(5) *Chela clupeoides* though not 100 per cent effective in controlling *cyclops*, can certainly be preferred to chlorination in view of its low cost and easy availability. Chlorination however can be done a few times before May or June every year when there is maximum infection.

Introduction of *Chela* can be done with advantage nearly 7 days after a preliminary chlorination in any water-piece. This chlorination will get rid of *cyclops* as well as all other fish enemies like *snakes, frogs, etc.* Once 500–1,000 *Chela* are introduced in a water-piece there is no need for restocking. They will multiply in hundreds and feed on all the organisms including *cyclops* in the plankton. Thus, the infection could be most effectively checked in course of time. There will also be enough stock of *chela* for distribution to other infected waters.

I express my thanks to Dr. Ramakrishnan, of the Public Health department for having suggested suitable places in South Arcot District for starting the experimen . My thanks are also due to the Health Inspector, Guinea Worm Research, Gingee, for constant help during my monthly visits to Alampoondi village.

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STATEMENT I.—*Showing the number of organism per dip from Alampoondi wells from March* 1957 *to February* 1958.

Period.	*Experimental well.*			*Control well.*		
	Larval Crustacean.	*Cyclops.*	*Other Crustaceans (Daphnids).*	*Larval Crustaceans.*	*Cyclops.*	*Other Crustaceans, (Daphnids).*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
March 1957	170	88	99	Nil.	Nil.	Nil.
April	5	16	Nil.	23	37	15
May	73	159	24	Nil.	745	12,603
June	155	85+(3)	37	327	1,528	11,142
July	67	31+(8)	47	164	98	628
August	13	31+(12)	12	51	18	1,537
September	9	6	7	20	23	52
October	8	8+(1)	4	4	33	183
November	14	55	205	21	420	160
December	30	8	6	2	4	337
January 1958	19	21	15	16	12	57
February	68	7	1	180	166	69

NOTES.—(1) Figures within brackets indicate Diaptomus which is not a host of Dracontiasis larvae.
(2) *Eucyclops leucarti*, which is intermediate host of the disease is the common cyclops recorded here.

STATEMENT II.—*Showing the data of cyclops density per dip in fish introduced and control wells, from April* 1956 *to March* 1957.

Month.	*Well with chela.*	*Control well.*	*Month.*	*Well with chela.*	*Control well.*
(1)	(2)	(3)	(1)	(2)	(3)
April 1957	16	37	October	(8+1)	33
May	159	745	November	55	420
June	85	1,528	December	8	4
July	31+(8)	98	January 1958	21	12
August	31+(12)	18	February	7	166
September	6	23	March	..	2

—:o:—

A PRELIMINARY NOTE ON THE EXTERNAL GILL IN THE HATCHLINGS OF MYSTUS AOR (HAM) FROM THE 'SPAWNING PITS' IN BHAVANISAGAR RESERVOIR

BY

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Successful spawning of a fish is the vital factor that decides its ultimate fishery in any impounded multipurpose reservoir. Investigations on the spawning grounds and their relative accessability by breeders are being carried on for each individual fishery at the Fresh Water Biological Station, Bhavanisagar. The two important fishes that have successfully established themselves and contribute nearly 25 per cent each of the experimental andings are *Puntius dubius* (Ham) and *Mystus aor*. A detailed paper on the Biology of *Puntius dubius* with reference to its growth and repopulation is under publication. The investigation on *Mystus aor* showed they become gravid by February and March and migrate from the reservoir towards the top waters for a very short distance. The narrow and yet not too deep lacustrine area with the gentle flow of the river clearly and perceptibly felt are the favourite spawning grounds. In these flats of depth varying from 1 metre to 3 metres the spawners select clay soil protected over a small rock, a dead stump of a tree, or even a twig safely inbedded in the soil and scoop pits varying from 8 c.m. to 15 c.m. deep and 38 c.m. to 56 c.m. in diameter, the size depending upon the size of the breeder. The intensity of the breeding can be visualised from the over 100 abandoned spawning pits counted in the exposed stretch due to water level going down within a distance of 150 metres on either side.

Between 28th March to 1st April 1962, the live 'spawning pits' were dived for and examined. The presence of the lethargic spawner, which happened to be the males in all the cases, was a sure indication of the availability of spawn. The contents of the pit were scooped out by hand. Stages from 8 m.m. to 3·5 c.m. were collected. The stages are being sketched and studied in detail. The water over the pit was turbid and laden with fine silt. It is likely the parent was over the pit and constantly aerating them. The mouth had opened out in hatchlings of 9.m.m. and above. In earlier hatchlings (8·3 to 8·5 m.m.) there was in addition, a cluster of four-lobed external gills projecting out from the posterior-most gill arch on each side. Under the microscope, the circulation of the colourless blood in these external gills was seen. This is a very interesting observation of adaptation in a species of a growing hatchling, in an ecological medium of low oxygen and a fair amount of laden silt. The development of external gills in fish Embryos have been recorded in all elasmobranchs, dipnoans, *Polypterus* and *Amia* (Fry 1957).

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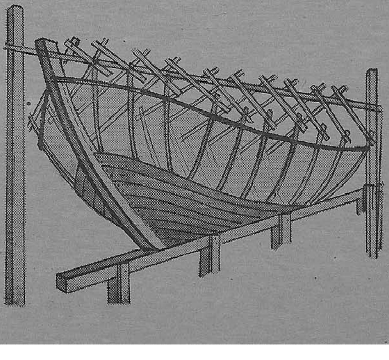

GOVT. FISHERIES BOAT BUILDING YARD, MARINA, MADRAS-5.

BUILDERS OF 30 FT. PABLO TYPE OF BOATS WITH 30 H.P. ENGINES FOR FISHERMEN FOR DEVELOPMENT OF MECHANISED FISHING.

SEX DIMORPHISM IN BARBUS CURMUCA (HAMILTON)

BY

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Barbus Curmuca is one of the common carps occurring in the Periyar lake. During a survey of the fish fauna of this lake, 182 specimens of this carp were collected and examined in detail for the sex differentiative characteristics about which a preliminary note has been given by Raj (1955).

The specimens ranged from 40 to 401 m.m. in size. There were 77 males and 105 females. Maximum size noted was 410 m.m. in the case of male and 326 m.m. in female. The general colour pattern could be distinguished in three size-groups as shown below.—

Part of body.	40–100 *mm. size specimens.*	101–200 *mm. size specimens,*	210 *mm. and above sizes specimens.*
(1)	(2)	(3)	(4)
1. Body	Golden-yellow with silvery Ventral surface.	Light grey ..	Upper half light grey, Lower half light with silvery tinged scales.
2. Paired fins ..	Grey with orange-in-between.	Grey with orange tinge.	Dark grey with white *fringes.*
3. Anal fin ..	Nearly same length in both sexes.	Nearly same length in both sexes.	Longer in females.
4. Caudal fin ..	Grey with golden tinge and orange blotch.	No orange blotch.	No orange blotch.
5, Eyes	Red rim present.	Red rim present.	Red rim present.

The pearl organs (horny tubercles) are the conspicuous sex characters of the males. These organs first appear as 1—3 tiny specks when the fish is about 130 m.m. in length, and thereafter form four to five prominent horizontally parallel rows from the snout to the eye. The number of pearl organs is about 16, 15, 20, 20 and 4 from the upper row downwards.

In the case of the larger females, no such characters are observed. The anal fin is distinctively longer than in male and even extends beyond the base of the caudal in some cases.

Sexual maturity as revealed by gonadial development is attained at 120-130 m.m. size in the male and 130–140 m.m. size in the female, the left ovary attaining an average of 64 m.m. in length and containing about 1,940 ova whereas the right ovary averages 70 m.m. in length containing 1,405 *ova. The ripe ovarian egg is* 1·4 *to* 1·8 m.m. in diameter. The ovary weighs 9 gms. in weight and 12 c.c. in volume on the average.

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries *(I.M.B.) for affording facilities* for conducting the study.

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AN INSTANCE OF GONADIAL ABNORMALITY IN SARDINELLA SIRM

BY

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The *ovary of Sardinella Sirm* is asymmetrical, the right one being larger than the left. But in a specimen examined on 13th March 1961, the right ovary was absent totally without any trace and the left ovary occupied the entire abdominal cavity. This ovary measured 75 mm. in length and 4·5 gm. in weight and was in V stage of maturity containing transluscent eggs. The fish measured 185 mm. in length and 63 gm. *in* weight. This is the first instance of such gonadial abnormality in this species of Sardine.

PRELIMINARY STUDIES ON THE USE OF INORGANIC FERTILISERS TO INCREASE FISH PRODUCTION

BY

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Introduction.

The importance of fish as an indispensable item of nutrition for a country like India needs no emphasis. Though efforts have been made in recent years to increase fish production in this country, a great deal more of attention has to be directed to increase the productive potentialities of inland waters. There are two established methods by which fish-yield could be increased in the fresh water ponds—one by artificial feeding and the other through fertilisation. The former method has been known to be in vogue in China in the 4th and 5th century B.C. (Neess, 1949), but the application of chemical fertilisers to increase fish production has been developed only recently. The role of fertilisers has been the subject of study by several scientists and fishery workers for many years (Swingle and Smith, 1947) Neess 1949, Mortimer and Hickling 1954, Demoll 1925, and Holden 1959). Though a number of experiments on application of fertilisers have been carried out in temperate waters; such detailed studies have not been carried out under tropical conditions. Mortimer (1954) while reviewing the role of fertilisers in fish ponds had pointed out the complete absence of information on the effects of artificial enrichment in tropical ponds and the need for experimental work.

It has been confirmed by detailed experiments (Demoll, 1946, Schaeperclaus, 1958) that additions of fertilisers can, roughly double the productivity of European carp ponds. It can safely be anticipated that higher fish yield could be achieved by judicious addition of fertilisers in tropical fish ponds in view of the increased growth rate at higher temperature (Sklower, 1950). Hence, preliminary studies to assess the value of inorganic fertilisers in increasing fish production under tropical conditions were initiated at the Fresh Water Biological Station, Bhavanisagar.

Experimental methods.

The experiments were conducted in cement tanks of size $6 \times 3 \times 1{\cdot}5$ metres. All the tanks were filled with the same type of soil up to 15 cm. depth, filled with water and then treated with fertilisers. The application of fertilisers to the cement tanks were made by broadcasting. Equal number of fingerlings were then introduced in all the tanks. At the end of the experiments the tanks were drained and the surviving fishes were weighed. Increase in production in kg/ha/year was calculated based on the total increase in weight in all the fishes.

Results :—Series 1.

In the first series of experiments 4 tanks were taken up for study. *Tilapia mossambica* was the test fish used. All the tanks were uniformly stocked at the rate of 3,000 fingerlings/acre. On account of the importance of nitrogenous and phosphatic fertilisers, these two fertilisers in the form of ammonium-sulphate and super phosphate were chosen for the present experiments. Combination of ammonium-sulphate and superphosphate in the ratio 1:1 was also tried. One cistern was kept as control without the addition of any fertilisers. Fertilisers were applied to each tank once at the beginning of the experiment at 100 kg/ha and again after 30 days at 200 kg/ha. Total rate of fertilisers treated with was 300 kg/ha in each tank and the experiments were conducted for 3 months. The results are tabulated below :—

TABLE I.

Experimental Series I.

Treatment.	*Survival.*	*Percentage increase in weight.*	*Production kg/ha/year.*
Control	87	2,000	650
Ammonium sulphate ..	60	1,900	510
Superphosphate	73	6,200	1,735
Ammonium sulphate + superphosphate.	82	5,800	1,760

From the results tabulated, it is seen that the addition of superphosphate had significantly increased fish production. Combination of ammonium sulphate and superphosphate has increased the fish yield to 1,760 kg/ha as compared to 650 kg/ha in the control. Ammonium sulphate alone in fact had decreased the production and survival is also 60 per cent as against 87 per cent in the control tank. Moreover ammonim-sulphate itself had not in any way contributed to additional production when applied in combination with super-phosphate.

Regular plankton analysis was not carried out. But a dominant bloom of *Euglena* was observed in the tank treated with ammonium sulphate. It is apparent that there has been proportionate increase in the plankton bloom especially *Chlorophyceae* but there has not been any corresponding fish growth in the tank which could only mean that either the phytoplankton produced by application of ammonium sulphate was not consumed by the fish or that the ammonium sulphate added has a detrimental effect on the growth of fish. Depressing effect of ammonia on fish growth is well known (Kawamoto, 1961, Philips *et al* 1947).

Results—Series II.

In the second series of experiments in addition to ammonium sulphate and super-phosphate the effect of potash applied as muriate of potash (60 per cent K_2O) was also studied. In view of the encouraging results obtained with superphosphate, combination of superphosphate with ammonium sulphate and with potash were tried. The experiment was conducted over a period of 6 months, applying the fertilisers at 200 lb./ha. once in two months. Two species of fishes were introduced, *viz.*, *Tilapia mosambica* and *Labeo* species at the rate of 5,000 fingerlings/ha. Summary of results are presented in Table No. II.

TABLE II.

Experimental Series II.

Treatment.	*Percentage of survival.*	*Percentage increase in weight.*	*Production kg/ha/year.*
Control	20	266	38
Ammonium sulphate ..	20	473	95
Superphosphate	46	630	491
Potash	41	305	174
Superphosphate + Ammonium sulphate.	40	436	324
Superphosphate + potash.	50	671	532

Comparison of results clearly shows that superphosphate and potash together increased the fish production to 532 kg/ha against 38 kg/ha in the control tank. The survival too was maximum in the tank which was treated with superphosphate and potash. Next best yield was noted in tank treated with superphosphate alone, rather than in superphosphate and ammonium sulphate combination. This confirms the findings in the previous series. Phosphorus is the important single fertiliser as affirmed by many workers. The application of potash alone raised the fish production only to 175 kg/ha which is very much less than the effect of superphosphate when applied alone. It is shown from the above two series of experiments that the effect of ammonium sulphate in fish production is negligible. The results also show that potash is a superior fertilisers for application in combination with superphosphate.

Unfortunately the survival of *Labeo* species was too low for reasons not very clear. *Tilapia* bred profusely in all the cisterns and a large number of fry and fingerlings were collected. Breeding of *Tilapia* together with low survival of *Labeo* species might have been responsible for the low production in this set of experiments.

Results—Series III.

The effect of inorganic Nitrogen in the form of urea on fish growth was taken up for study in the third series. Besides superphosphate and potash, two different ratios were also tried to find out the optimum dosage. The application of fertilisers was altered to fortnightly treatment for three months to find out whether frequent application has any beneficial effect. The dosage applied was 50 kg/ha. Fishes introduced were *Catla catla*, *Labeo rohita* and *Cyprinus carpio* at the rate of 3,000 fingerlings/ha. The summary of results are presented below in Table No. III.

TABLE III.

Experimental Series III.

Treatment.	*Survival percentage.*	*Percentage increase in weight,* *Labeo rohita.*	*Percentage increase in weight,* *Cyprinus carpio.*	*Production kg/ha/year.*
Control	63	168	74	112
Superphosphate + potash (5 : 1).	94	1,753	698	4,494
Superphosphate + Potash (2 : 1).	100	1,758	90	2,640
Superphosphate + + Urea (4 : 1).	69	1,873	74	1,932
Urea + Potash (5 : 1).	Nil.	Nil.	Nil.	Nil.

The table indicates that the best results were obtained with superphosphate and potash when applied in the proportion of 5 : 1, the production being 4,494 kg/ha almost twice that of the result obtained with the same combination when applied in the proportion of 2 : 1. The survival too has been very high with these two combinations. The effect of superphosphate and urea in the ration 4 · 1 gave fairly good results perhaps due to the effect of superphosphate only, the effect of urea being negligible as can be seen with the combination of urea and potash in the ratio 5 : 1. Initially dense growth of *Spirogyra* was noticed in the bottom for a month in the tank with urea and potash (5 : 1) but later *Chlorophyceae* blanketed this. There was zero survival of fishes in this tank. The excessive planktonic bloom might have caused the mortality of all the fishes by de-oxygenation or by release of ammonia. Manuring in this series has produced considerable increase in crop compared with the previous experiments. This can partly be attributed to the more frequent application of fertilisers and partly to the stocking of more compatible species.

Changes in water conditions.

The chemical changes following the application of fertilisers were also studied in the third series. Soil and water samples were collected before manuring, then six days after manuring and were analysed. Soils were analysed for their available nutrients (Spurway, 1946). Water samples were analysed by standard methods (APHA 1956). Changes in pH, dissolved oxygen, total dissolved solids and loss on ignition are represented in Fig. 5. Marked fluctuations were observed in dissolved Oxygen, pH and alkalinity in the fertilised tanks as compared with those of the control tank and this could be due to the increased biological activity of the fertilised tanks. (Hepher, 1958). Even though all water samples were collected between 8·0 and 9·0 a.m. to minimise the effect of photosynthesis, pH readings were above 9·0 and an appreciable amount of carbonate-alkalinity was present. Total dissolved solids which are known to be an indication of productivity of waters (Rawson, 1959) was found to be higher in all the treated tanks than in the control. Similarly loss on ignition (organic matter) was lower in the control tank. Ammonia was detected in the water only at certain times in tanks

treated with Urea, while it was not detected in other tanks. Ammonia was lost from the water within six days. Ammonia content was not estimated. Determination of potassium was also not made. Phosphorous concentration of the waters of cement tanks found by analysis before and during fertilisation are given in Table IV.

TABLE IV.

Phosphate content of waters of cement tanks in experimental series III (p.p.m.)

	Prior to application.	*Date of application of manures:* 3rd October 1961.	19th October 1961.	3rd November 1961.	14th November 1961.	5th December 1961.	21st December 1961.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Date of analysis	2nd October 1961.	29th October 1961.	25th October 1961.	N.E.	18th November 1961.	11th December 1961.	26th December 1961.
Control	Nil.	Nil.	Nil.	N.E.	Nil.	Nil.	Nil.
Superphosphate + Potash (5 : 1).	Nil.	0·02	0·02	N·E.	0·08	0·02	Tr.
Superphosphate + potash (2 : 1).	Nil.	Tr.	Tr.	N.E.	Nil.	Tr.	Nil.
Superphosphate + Urea (4 : 1).	Nil.	0·06	0·02	N.E.	0·16	Tr.	Tr.
Urea + Potash (5 :1). ..	Nil.	Nil.	Nil.	N.E.	Nil.	Nil.	Nil.

Dissolved inorganic phosphate was not detected in any of the tanks before the commencement of the experiment. It was absent in the waters of the untreated tank throughout the period of the experiment. In tanks manured with superphosphate, phosphate was detected in the waters in quantities of 0·02 p.p.m. after the first two applications. Rigler (1957) has shown that of the total phosphorous added to the surface, 77 per cent was lost from the water to the plankton and 3 per cent to the mud. The disappearance of the phosphate from the water may be due to many factors such as uptake by plankton, mud, etc. After repeated applications phosphate was present only in traces which clearly shows that the increased plankton produced had taken up immediately almost all of the phosphate added. This is seen in all cases with superphosphate treatment. Zeller (1952) also made similar observations.

Change in soil conditions.

The data on the analysis of soils before and at the end of the experiment are given in table V.

TABLE V.

Showing the concentration of soil nutrients with different fertilisers treatment.

Treatment.	*Control.*	*Super phosphate plus Potash* (5 : 1)	*Super phosphate plus Potash* (2 : 1).	*Super phosphate plus Urea.* (4 : 1)	*Urea plus Potash* (5 : 1)
Ammonia—					
(A)	2	2	2	2	2
(B)	5	15	10	25	25
Phosphate—					
(A)	Tr.	0·5	0·25	0·25	0·25
(B)	0·25	0·75	0·75	0·75	0·75
Calcium—					
(A)	30	30	30	30	30
(B)	40	40	40	40	40
Iron—					
(A)	Tr.	Tr.	Tr.	Tr.	Tr.
(B)	2	2	2	Tr.	2
pH—					
(A)	7·8	7·3	7·3	7·3	7·5
(B)	6·5	6·5	6·5	6·5	6·5

NOTE.—A. Before application of fertilisers.
B. At the end of the experiment.

Though initially available ammonia was present in all the tanks in concentration of 2 p.p.m. after repeated application of fertilisers at the end of the experiment a difference was noted in the total content of ammonia in the different tanks. That treated with Urea had a higher ammonia content than other tanks. Occurrence of ammonia even in the unfertilised tanks indicated that Nitrogen was not the factor limiting algal growth (Zeller, 1952), Neess (1949) is of opinion that bacterial fixation can provide most if not all of the nitrogen required by a pond. Available phosphorus was present only in traces in the control tank while it was present at 0·025 p.p.m. in all the other tanks. This might have been due to the effect of previous manuring. At the end of the experiment slight increase in the available phosphorus content has been noted in all the tanks, the increase being greater in tanks getting superphosphate treatment. Soil pH decreased in all the tanks, while available Calcium and Iron content increased in all the tanks.

Discussion.

From the experiments it could be seen that artificial enrichment of a pond could bring about considerable increases in fish yield and that superphosphate is the efficient single fertiliser. The striking effect of phosphorus when applied as superphosphate on fish yield has been noted by many workers (Weimann 1939, Wunder 1949). It appears that phosphorus is the most important limiting factor controlling organic production in natural waters. Phosphate fertilisers are said to stimulate the activity of nitrogen-fixing bacteria and growth of plankton (Demoll 1925). Further, phosphate fertilisation seems to have a direct beneficial effect on fishes through a more efficient utilisation of dissolved calcium from water, which has been fertilised with phosphate (Phillips *et al* 1956).

Opinions differ regarding the beneficial effect of inorganic nitrogen fertilisers on fish growth since variable results are reported. However, the experiments conducted here confirm the viewth at inorganic nitrogen in the form of ammonium sulphate and urea does not have any favourable effect on the rate of fish production and they may even

have harmful effects on fish (Walter and Nolte 1929). It has often been observed that nitrogenous fertilisers have stimulating effect on the growth of phyto-plankton (Swingle and Smith 1938) as noticed by the *Euglena* bloom.

From the results it can also be concluded that potassium alone is not a particularly effective fertiliser though Demoll (1925) obtained increased production by using potassium alone. When added in combination with phosphate, the yields are much better than when phosphate alone was applied. Holte (1932) also obtained similar differences in yield. Soils may respond better to potash where potassium deficiency existed.

Summary.

From the three series of experiments conducted it is evident that the effect of phosphate on the growth of fish is very striking. Combination of superphosphate and potash in the ratio 5 : 1 appears to be by far the most suitable. The optimum dosage seems to be 50 kg/ha applied to fortnightly intervals Inorganic nitrogen in the form of ammonium sulphate and urea have adverse or negative effect on the fish growth. It should also be mentioned that the above experiments were carried out in cement tanks under controlled conditions and these obviously have certain limitations with regard to space, temperature seepage, etc. Similar studies have to be undertaken in natural ponds to confirm the above findings. However, the conclusions arrived at lead to highly optimistic assessment of the value of phosphatic fertilisers in fish ponds.

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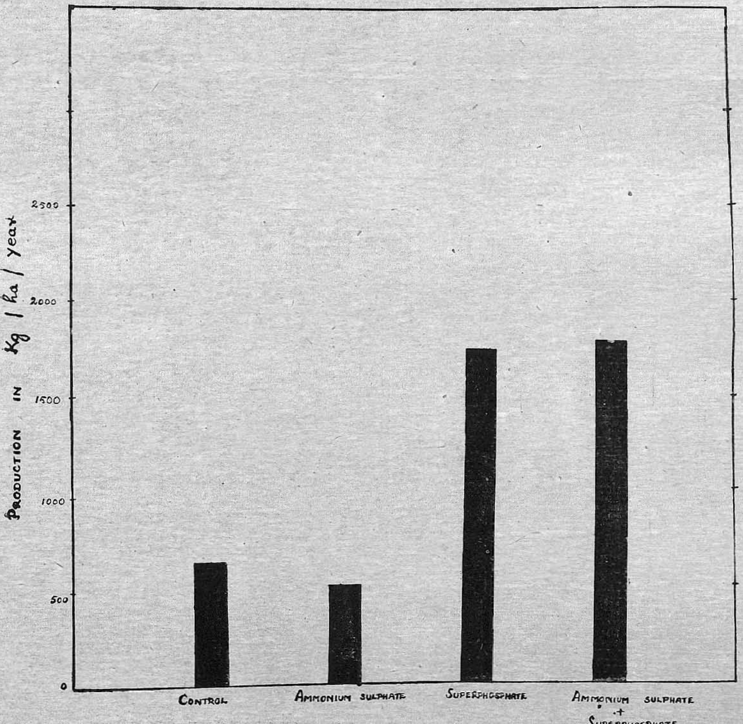


Fig. 1—Histograms showing the effect of fertilisers on fish production—Series I.

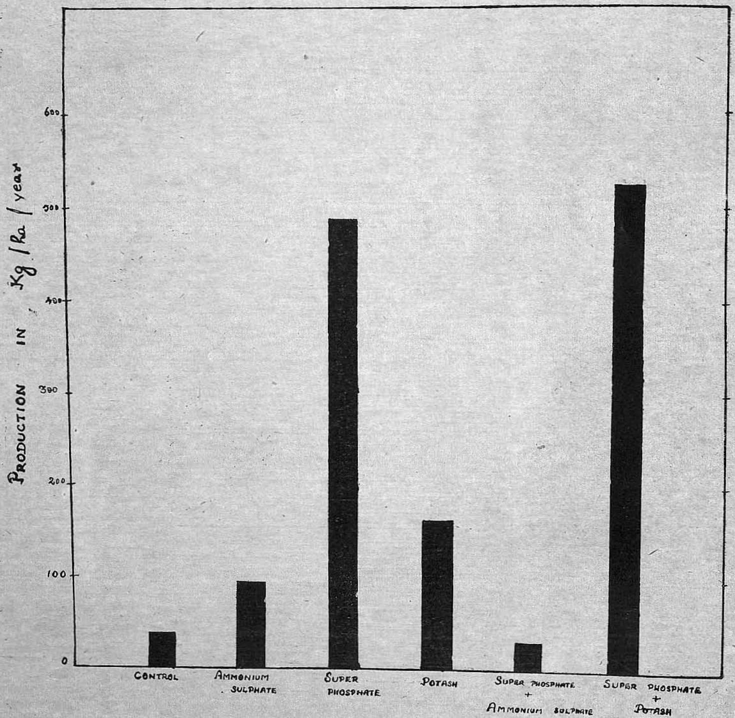


Fig. 2—Histograms showing the effect of fertilisers on fish production—Series II.

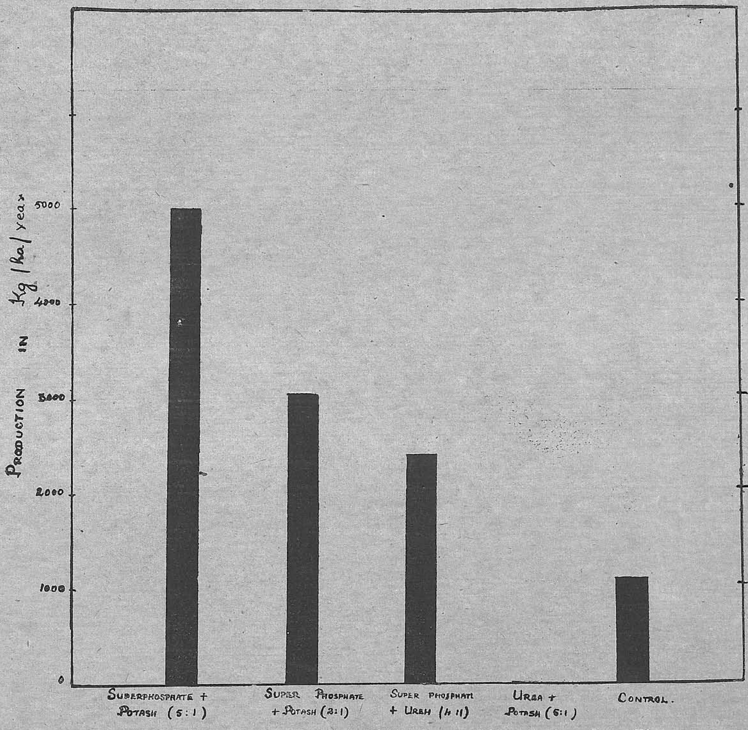
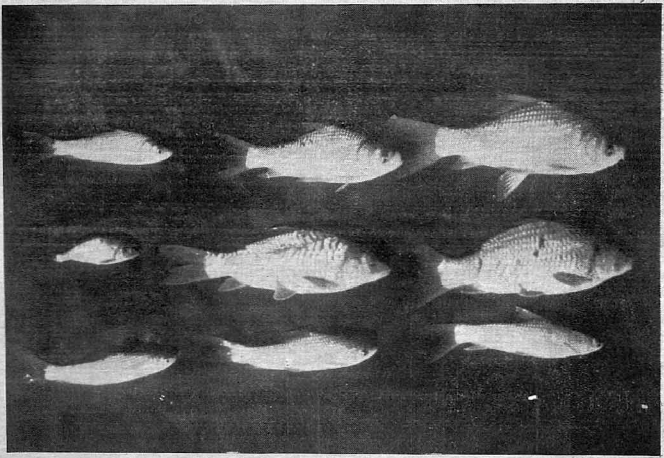


Fig. 3—Histograms showing the effect of fertilisers on fish production—Series III.



A

B

C

1 2 3

Fig. 4—Effect of Fertilisation on the growth of Fishes.

STOCKED : A—Catla Catla. B—Cyprinus Carpio. C—Labeo Rohita.

1. Average size in Control tank.
2. Average size in Tank treated with superphosphate and Potash 2 : 1.
3. Average size in Tank treated with superphosphate and Potash 5 : 1.

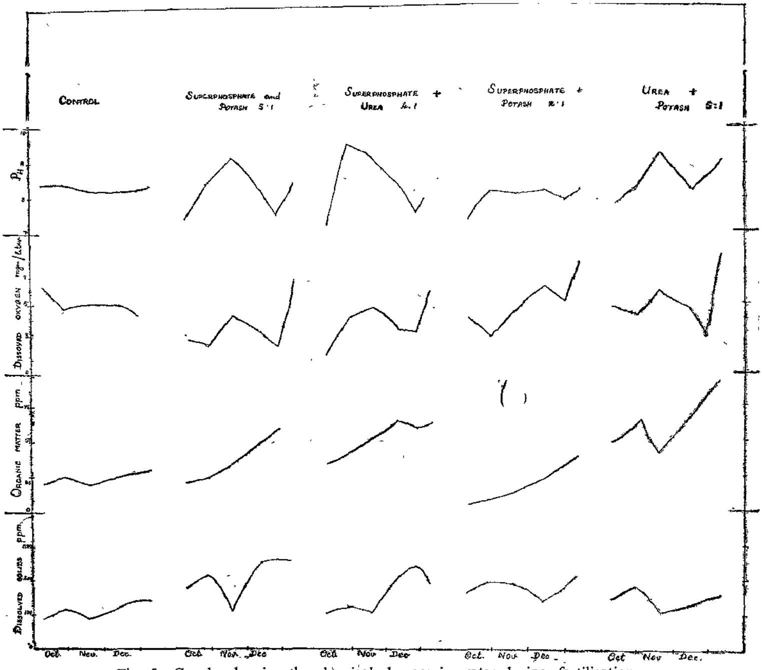


Fig. 5—Graphs showing the chemical changes in water during fertilisation.

A SURVEY OF THE HYDROBIOLOGY AND FISHERIES OF THE COOUM RIVER

BY

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1. Description of the Cooum River.

The river Cooum starts from a surplus channel of a tank in the village Cooum situated in the Conjeevaram Taluk of Chingleput District. The river runs for about 40 miles before it enters the Madras City. Within the City limit itself it takes a meandering course for about seven miles and finally it joins the sea, a little to the south of Fort St. George. The total catchment area for the river is about 96 square miles.

Within the City limits there are ten bridges across this river which are as follows :—

(1) Aminjikarai Bridge.
(2) Nungambakkam Railway Bridge.
(3) Munro's Bridge.
(4) College Bridge.
(5) Commander-in-Chief Bridge.
(6) Harris Bridge.
(7) St. Andrew's Bridge.
(8) Law's Bridge.
(9) Willingdon Bridge.
(10) Napier Bridge.

After entering into the City and just before joining the sea, the river splits up into two branches which join again just before the Napier Bridge thus forming the Island Ground. The Buckingham canal joins the northern arm of the river and continues up to the southern arm of the river. This portion of the river is navigable. From the Southern arm the South Buckingham canal takes off.

The river Cooum is not a perennial one. It has flow only during North-East Monsoon from October to December. Water from about 7 square miles area of the City drains into the river. At the mouth of the river, i.e., the place where it joins the sea it is closed by a sand bar throughout the year except at times when there are heavy rains. The sand bar is due to deposition of sand at the mouth of the river by sea currents. Due to the tidal action of the sea the depth of water in the river varies greatly, especially at the portion of the river near the sea. Water level in the river falls when there is low tide and water level rises when there is a high tide. When the level of the water goes below plus 1·50 feet above mean sea level the shoals in the river covered with bottom deposits get exposed and cause obnoxious odours. In addition to this, the sullage from several un-sewered areas of the City finds an entry into this river by means of the Buckingham canal and causes nuisance. Another main reason for the unsatisfactory condition of the river is due to the water remaining stagnant for a major period of the year.

The river is practically dry at places above the railway bridge at Nungambakkam except for a few ditches having rain water collections. Storm water drains of the city have also been connected to the river at various points. This river is polluted in many respects and the major sources of pollutions are as follows :—

(1) A large number of slum areas are located on either side of the river margin at various places starting from Nungambakkam Railway Bridge up to Law's Bridge at mile No. 1. These slums contribute all types of pollution such as utensil washing, cloth washing and sullage water, etc.

(2) Drain bringing waters from cattle yards also joins the river near Munro's Bridge.

(3) The pits and ditches having rain water collections at places upstream of Nungambakkam Railway Bridge are polluted by washing of clothes by dhobies.

(4) People residing on the banks of the river dig pits on the river and store cow dung. People also defecate on the banks of the river in spite of public privies provided. Thus, human and animal wastes are washed into the river during rains.

(5) During heavy rains overflow of sewage (i.e., from Napier Park sewage pumping station) is also allowed to enter the river.

(6) Further, wastes from automobile workshops situated on the banks of river, garbage and rubbish from houses, shops and streets thrown on the banks of the river also contribute to the pollution of the river.

Owing to the heavy pollution of the river especially in upper reaches there is a small nuisance on most occasions owing to the prevalence of septic conditions. At certain reaches, i.e., portion between Munrow's Bridge and Willingdon Bridge, the dissolved oxygen content in water is as low as four parts per million parts and there is no fish life in that reach.

But the dissolved oxygen content in the water at portions close to Napier Bridge appears to be high which may mainly due to wind action and surface aeration.

The obnoxious odours appear to result when the level of the water in the river goes below plus 1·5 feet and it looks that smell nuisance can be minimised by maintaining a minimum water level of plus 1·5 in the river.

A sketch showing river Cooum and the bridges, etc., is appended.

2. Purpose and Method of Survey.

A regular monthly survey was conducted in 1958–59 in 4 sections of the river at Aminjikarai Bridge, Munro's Bridge, St. Andrew's Bridge and Napier Bridge, with a view to note the Physico-Chemical nature of the water, its plankton, fishery, number of fisherfolk, the craft and catch-effort, etc., and also to note if *Tilapia* would breed in the river. In 1961, another periodical survey of the same sections of the river was made along with stocking of *Tilapia* in the river. This report deals with both the surveys.

For nearly seven miles the river flows through the city and the estimation of population, of fish statistics, etc., are only confined to this region of the river.

3. Physico-Chemical Factors (Tables A1—A4).

The water colour, temperature, turbidity, depth and bottom for each section can be easily observed from the tabular statements. The last section will show in addition, the nature of the bar during the month. Usually the bar is open for two to three months during the year, i.e., from November-January but in 1961, due to heavy flooding in the river an artificial canal was cut by Public Works Department into the sea to prevent flood into the Madras City. Hence, the bar was open even after February.

Section I—Aminjikarai Bridge.—During January-May, September and November the water was clear, otherwise it was greenish or muddy. Temperature ranged from 26 to 32°C and turbidity from 44 to 56 c.m. Maximum depth was 9 ft. in November. Bottom was sandy at the banks and dark and clayey in the interior.

Section II—Munro's Bridge.—Water was clear from March to June and September, otherwise slightly muddy or slightly greenish. Temperature ranged from 26 to 33°C. Turbidity ranged from 38 to 44 c.m. Maximum depth was 7 ft. in November. Bottom was slushy and clayey.

Section III—St. Andrew's Bridge.—Water was never clear but was either blackish and muddy, reddish or dirty. Temperature ranged from 26 to 35°C. Turbidity ranged from 18·2 to 37·5 c.m. Maximum depth was 8 ft. in November. Bottom was of loose clay.

Section IV—Napier Bridge.—Water was clear from January to March, otherwise greenish, reddish, blackish or muddy. Temperature ranged from 26 to 36°C. Turbidity ranged from 34 to 45 c.m. Maximum depth was 10 ft. in November. Bottom of clean sand. Bar was open between November and January in 1957–59 and between November—February in 1961.

The water was analysed in July 1961 and showed the following data :—

Section.	*pH.*	*O_2 of cc/L.*	*CO_2 of P. small pm.*	*CO_3 of P. mall pm.*	*$Bico_3$ of P. small pm*
I	7·2	3·2	2·5	1·8	7·8
II	7·4	1·47	2·6	1·8	8·1
III	7·2	1·47	3·0	3·0	27·3
IV	7·6	3·29	2.2	2·4	26 5

4. Plankton (Tables B1—B5).

Plankton consisted of the following items of green algae, blue-green algae, Diatoms, Desmids, Rotifers, Cyclops, Daphnids, Flagellates, young crustacean larvæ, insect larvæ, etc.—

Ankistrodesmus, *Pleurococcus*, *Pediastrum*, *Microspora*, *Ophiocytium*, *Tetraspora*, *Spirogyra*, *Ulothrix*, *Dictyosphoerium*	Green Algae.
Navicula, *Melosira*, *Synedra*, *Cyclotella*, *Fragillaria*	Diatoms.
Closterium, *Gonatozygon*, *Cosmarium*, *Merotaenium*, *Netrium*	Desmids.
Cyclops	.. Copepods.
Macrothrix, *Sida*, *Daphnia*	Daphnids.
Salpina, *Aneurea*, *Floscularis*, *Polyarthra*, *Dinocharis*, *Gastropus*, *Suriella*	Rotifers.
Euglena	.. Flagellates.
Volvox, *Pandorina*, *Eudorina*	Colonial Flagellates.
Carchesuim	— Colonial Ciliate.
Nauplius larvae	
Insect larvae	
Cypris	

Table B5 showing number of months of occurence of the organisms in the 4 sections.

Plankton organism.	*I.*	*II.*	*III.*	*IV.*
Diatoms	11	5	9	11
Rotifers	8	4	3	3
Green algae	6	10	4	5
Blue Green algae ..	5	4	8	6
Desmids	4	6	8	9
Daphnids	2	1	2	1
Flagellates	2	Nil.	2	1
Nauplius	2	4	1	1
Cypris	1	Nil.	Nil.	Nil.
Copepods	Nil.	4	3	3
Colonial Ciliates —	Nil.	Nil.	1	Nil.

The tabular statement B5 shows the periodicity of the occurrence of the different items of plankton in the different sections of the river. In general, the following factors are observed from the above table :—

(1) Diatoms are the predominant plankton of the river and occur in 11 months of the year in I to IV sections. On the whole, diatoms occur in all the sections of the river.

(2) Desmids are next abundant in II, III and IV sections of the river, while poor in the I section.

(3) Green algae occur in I and II sections more abundantly and are richest in section II.

(4) Blue-green occur in III and IV sections and is poorly represented in I and II sections.

(5) Daphnids, Flagellates, Nauplius, cypris, copepods, and colonial ciliates are comparatively rare in the river, because of unfavourable water conditions of the river throughout the City.

(6) Copepods were present only between August and November between II and IV sections and was most abundant in August and September.

(7) On the whole cyclops are scarce in the river.

5. Fish Fauna (Table C1—4).

The studies of fishery is based on only catches from trial nettings during the survey. The following fishes and macro crustaceans were found :—

1 *Ambassis nama*	16 *Macrones Vittatus*
2 *Amblypharyngodon mola*	17 *Mastacembelus armatus*
3 *Anabas scandens*	18 *Megalops cyprinoides*
4 *Barbus stigma*	19 *Metapenaeus monoceros*
5 *B. ticto*	20 *Mugil* sp.
6 *Chanos chanos*	21 *Nuria danrica*
7 *Chela argentea*	22 *Ophiocephalus striatus*
8 *Diagramma orientale*	23 *O. punctatus*
9 *Discognathus lampta*	24 *Palaemon Lamarrei*
10 *Equula* sp.	25 *Penaeus indicus*
11 *Etroplus Maculatus*	26 *Rasbora daniconius*
12 *Gambusia affinis*	27 *Sillago sihama*
13 *Labuca atpar*	28 *Therapon jarbua*
14 *Lepidocephalicthys thermalis.*	29 *Tilapia mossambica*
15 *Lutjanus rivulatus*	30 *Trichogaster fasciatus*

In addition to the fishes, prawns and lobsters mentioned above, crabs and molluscs, are found in the river. Pila and Limnea are the common gastropods present in the Cooum. The following points can be noted regarding the fishery :—

(1) *Penaeus indicus* and *B. Stigma* occur almost throughout the year in the I section of the river. *Glossogobius* and other Public Health fishes also occur in this section.

(2) *Metapenaeus monoceros* and *Palaemon Lamarrei* occur through out the year except July and August in II section of the river. *Barbus stigma* occurs 7 months in the year. *Chanos* was collected in March from this section

(3) *Prawns* occur 6 months during the year in the III section . *Megalops* occur in 4 months of the year. *Gambusia* has been netted only from this section of the river.

(4) *Barbus* sp. was almost absent in the IV section of the river and was netted only once in November.

(5) *Megalops* was common in the III section of the river.

(6) *Mugil* sp. (mullets) occur in III and IV sections of the river being most common in IV section between January and March.

(7) *Sillago sihama, Equula* sp. *Diagramma orientale* and *Therapon Jarbua* were collected from IV section when the bar was open and continued to occur even after the bar was closed, up to March or April.

(8) *Tilapia* has been netted only thrice during the survey from I, II and IV sections of the river.

(9) It is strange to note that while all other varieties of indigenous fishes (both fresh water and marine) crabs prawns and molluscs are thriving in the Cooum, only *Tilapia* has not established itself so far. Evidently, it is not the food conditions. Possibly other conditions are not suitabe for the thriving of Tilapia.

6. Gut analsis of Fishes—

(1) *Ambassis*: Blue-green algae ; Green algae Diatoms.

(2) *Ambly pharyngodon* : Green algae (*Ankistrodesmus Botryococcus ; Pleurococcus ; Diatoms*).

(3) *Anabas* : Insect appendages, Green algae ; Diatoms ; Fish eggs.

(4) *B. Stigma*: Rotifers ; Diatoms ; Desmids ; Volvox.

(5) *B. ticto* : Rotifers ; Diatoms ; Desmids ; Algae.

(6) *Chela* sp : Rotifers (*Conochilus*, Rotifers) *Cyclops*, Copepods ; Diatoms ; Green algae (*Coelastrum ; Dictyosphaerium*).

(7) *Diagramma* sp. : Young crustaceans ; Rotifers ; *Macrothrix , Nauplius, Daphnids, Cyclops* , Rotifers.

(8) *Discognathus* sp. ; Green algae ; *Nauplius* larvae.

(9) *Equula* sp : Desmids ; Diatoms ; Green algae.

(10) *Etroplus Maculatus* ; Copepods, Diatoms ; Green algae (*Spirogyra*) *Oedogonium.*

(11) *Gambusia affinis* ; Daphnids ; Cyclops ; Diatoms.

(12) *Glossogobius* : Green algae ; flagellates ; Diatoms.

(13) *Gobius* : Diatoms ; Desmids.

(14) *Lepidocephalicthys* sp. : Desmids ; Diatoms ; small scales.

(15) *Lutjanus* sp. : Nauplius ; copepods ; crustacean appendages ; Diatoms ; Algal filaments.

(16) *Macrones vittatus* : Cyclops ; Desmids ; Diatoms ; green algae ; crucigenia.

(17) *Mastacembelus* sp. : Diatoms ; Desmids ; Rotifers.

(18) *Megalops* : *Daphnia* ; *Crucigenia* ; *cyclops* ; *Diatoms*.

(19) *Mugil* sp. : Closterium Desmids ; *Synedra* ; *Navicula* ; *Suriella* ; *Pinnularia* ; *cymbella* ; Diatoms, Insect appendages ; *Polyarthra*; *Triarthra* ; *Notholca* ; Rotifers.

(20) *Nuria danrica* : *Botryococcus*, *Ankistrodesmus Pleurococcus* ; *Coelastrum*—Green algae.

(21) *Rasbora* sp : Crucigenia ; Green algæ ; Rotifers Nauplius larvae.

(22) *Therapon jarbua* : *Spirogyra* ; *Ulothrix*—Algae ; *Cymbella*, *Navicula*—Diatoms.

(23) *Tilapia mossambica* : Desmids ; Diatoms ; green algae ; *Crucigenia* ; Blue-green algae.

(24) *Trichogaster* sp. : *Cymbella* ; *Navicula*—Diatoms Green algae.

7. Statistics of Fish Landings (Tables D1—D4).

The fishery shown in these tables are those caught by the local fishermen of the particular section. The cost of fishes calculated for total value realised also varies from section to section according to the kind of fish, locality and prevailing market rate. This part of the report is compiled purely from statistics given by the local fishermen of the sections.

Number of fishermen were maximum in the III section (from Chintadripet down to the Gymkhana Club area) during the year. During November up to 50 fishermen were daily found fishing with Kacha Valai and rod and lines. As the bar was open, *Megalops* and Mullet fingerlings had come up into the river in thousands and this was the main attraction for the fishermen. Practically no fishing was done in this section in October. Next to St. Andrew's Bridge section, fishermen fished in large numbers in Munro's Bridge section. In Aminjikarai Bridge section and Napier Bridge section, the fishermen were fewer in number than those in the other 2 sections. During certain months of the the year, the Aminjikarai and Munro's bridge sections were dried up into little pools and narrow streams and there was usual flow only from the Connemara Bridge area.

Craft and Tackle.—All the fishermen in Aminjikarai bridge section used only cast nets. In Munro's bridge cast nets were the usual nets used with Kacha Valai in November and December. In St. Andrew's Bridge section Kacha valai was used mainly for fishing with rod and line in November and December. In the Napier Bridge section, January-May cast nets were used with rod and line in May. From June-September and December Kacha Valai was used.

Fishery (Table D1—D4).—Fishing was not done in III and IV sections in October. Inspite of this, section III has produced the maximum yield of 21,765 lb. and naturally more revenue to the fishermen of the area. I, II and IV sections have roughly produced an average of 15,000 lb. and an average revenue of Rs. 5,500—6,000.

8. Conclusions.

Tilapia thrives in most of the waters of the state and can stand high ranges of salinity in salt waters like the Kalimar lake in Manakudy. It has also established itself very well in the backwaters of Adyar river. Till 1958 *Tilapia* had not established itself in the Cooum river though the Inspector of Fisheries (Estuarine) had stocked the river with over 5,000 *Tilapia* seeds in 1958. About 39,400 *Tilapia* seeds ranging from 0·5 to 2·00 c.m. have been stocked in the different sections of the river and periodical trial nettings have been made by cast nets and Velon screen. The water temperature of Chetput fish farm and Cooum river is almost the same. *Tilapia* has not established itself satisfactorily in the Cooum and has been netted only thrice in 1961 from section I, II and IV.

The water analysis of Cooum showed a very low oxygen content, excess of Co_2, Carbonates and Bicarbonates in July 1961. The plankton, while rich in Diatoms and Desmids, is very poor in cyclops, and other phytoplankton. The oxygen requirement and feed of fishes vary from fish to fish and that is why perhaps when many other fresh water fishes, and salt water fish like *Megalops*, mullets, *Diagramma*, *Equulla* and *Therapon* thrive well with crabs, prawns, lobsters but Tilapia is unable to establish itself in this water. Small *Tilapia* seeds are perhaps unable to establish quickly. Nearly 5,000 *Tilapia* breeders of 15—20 cms. size have also been stocked in the river without any success. *Tilapia* recovered during my trial nettings were only 3—4 cms. in size and were evidently a few of the survived percentage that had existed in the river. It is however been reported that *Tilapia* was being marketed in some of the local markets. On enquiry these were reported to be caught from private tanks and Adyar river only.

Tilapia has not established itself successfully in Cooum. A thorough study of the Cooum water samples at different sections of the river compared with Chetput water is bound to show some factors which are causative in preventing the establishment of *Tilapia* in Cooum. Evidently the water conditions are not conducive to the growth of *Tilapia*. *Tilapia* if established will be a source of great revenue to the common fisher folk as even predators like *Notopterus* and Murrels cannot affect its population seriously, being a very prolific breeder.

The fishermen of the city who fish in Cooum thus have to depend for their income on the various indigenous fishes till such time as *Tilapia* is successfully established.

Acknowledgment.

I am indebted to Sri P. I. Chacko , Assistant Director of Fisheries, for guidance during the survey and in the preparation of this report.

TABLE A-1—A-4 PHYSICO CHEMICAL FEATURES.

SECTION I (AMINJIKARAI BRIDGE).

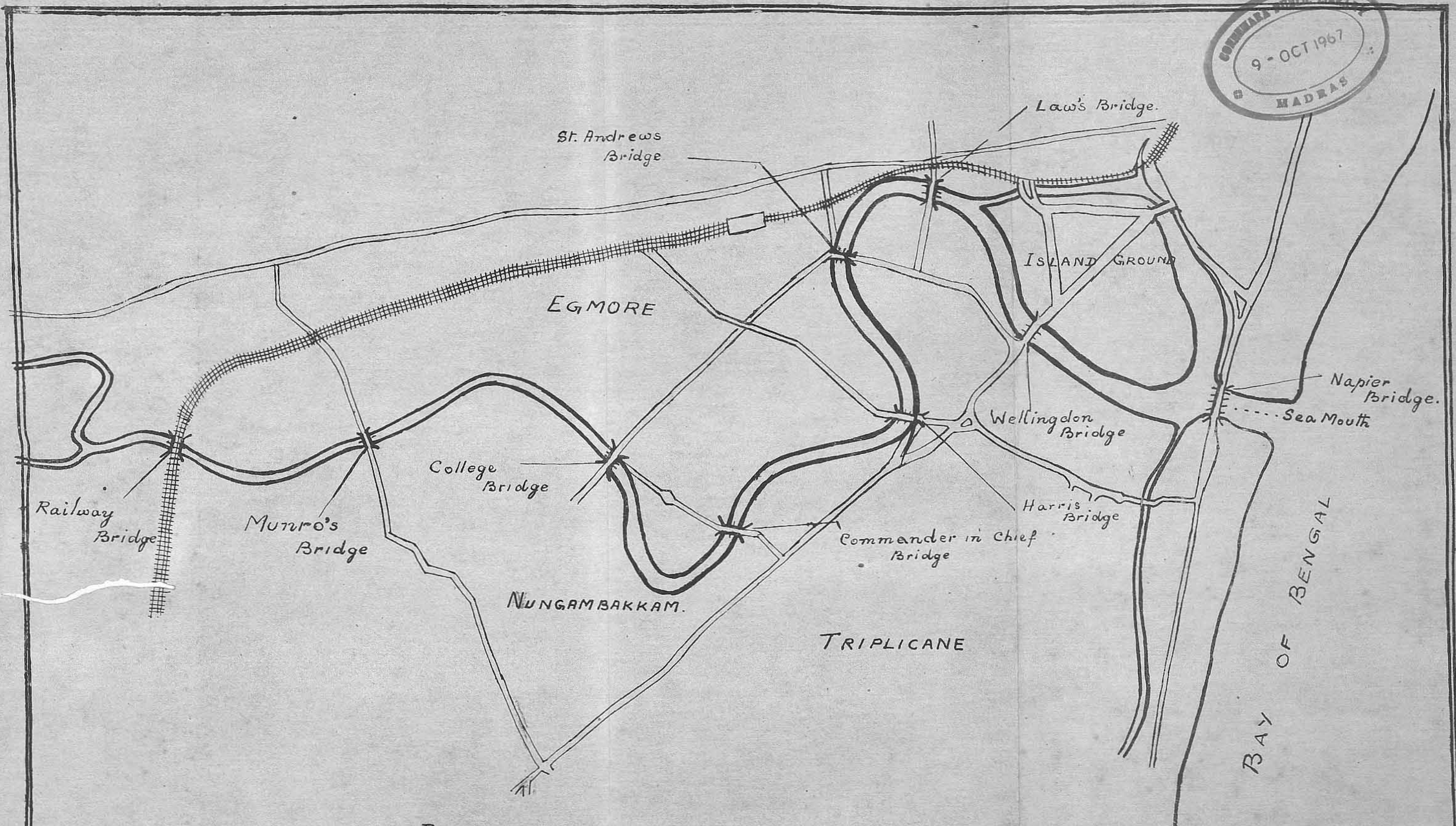
Table—A I.

Month.	*Colour of H2O.*	*Temperature in °C.*	*Turbidity in cm.*	*Depth in ft.*	*Bottom.*	*Nature of bar.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
January ..	.. Clear	26	52	2–8	Dark clayey and sandy at the bank.	..
February ..	.. Do.	27	50	2–8	Do.	..
March ..	.. Do.	28	46	1–7	Do.	..
April ..	.. Do.	30	44	1–7	Do.	..
May ..	.. Do.	31	46	1–5	Do.	..
June ..	.. Greenish	32	48	1–4	Do.	..
July ..	.. Do.	29	50	1–3	Do.	..
August ..	.. Do.	27	50	1–5	Do.	..
September	.. Clear	29	26	1–6	Do.	..
October ..	.. Muddy	26	52	1–7	Do.	..
November	.. Clear	29	52·5	2–9	Do.	..
December ..	.. Green turbid ..	26	52	2–9	Do.	..

SECTION II (MUNRO BRIDGE).

Table—A II.

Month.	*Colour of H2O.*	*Temperature in °C.*	*Turbidity in cm.*	*Depth in ft.*	*Bottom.*	*Nature of bar.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
January ..	.. Turbid	29	42	1–5	Slushy and clayey.	..
February ..	.. Slightly muddy.	28	42	1–5	Do.	..
March ..	.. Clear	29	40	1–4	Do.	..
April ..	.. Do.	31	38	1–3	Do.	..
May ..	.. Do.	33	39	1–3	Do.	..
June ..	.. Do.	33	39	1–3	Do.	..
July ..	.. Slightly blackish.	30	42	1–4	Do.	..
August ..	.. Slightly greenish.	30	40	1–4	Do.	..
September	.. Clear	30	39	2–5	Do.	..
October ..	.. Muddy	26	41	2–6	Do.	..
November	.. Do.	31	43·5	2–7	Do.	..
December ..	.. Clear	28	44	2–6	Do.	..



PLAN SHOWING THE COURSE OF RIVER COOUM
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SECTION III. (ST. ANDREWS BRIDGE).

Table—A III.

Month.	*Colour of H_2O.*	*Temperature in °C.*	*Turbidity in cm.*	*Depth in feet.*	*Bottom.*	*Nature of bar.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
January ..	.. Blackish	26	36	1–7	Very clayey loose clay.	..
February ..	.. Blackish and muddy.	28	30	1–6	..	..
March ..	.. Green and muddy.	31	20	1–6	..	..
April ..	.. Blackish and muddy.	35	20	1–5	..	..
May ..	.. Greenish ..	35	18	1–5	..	..
June ..	.. Blackish	34	20	1–4	..	..
July ..	.. Reddish	30	24	1–5	..	..
August ..	.. Do.	30	20	2–6	..	..
September	.. Dirty	30	18·2	2–7	..	
October ..	.. Muddy	28	37·5	2–8	..	..
November	.. Dirty	31	36·4	2–8	..	..
December ..	.. Blackish	28	36·5	2–7	..	..

SECTION VI (NAPIER BRIDGE).

Table—A IV.

Month.	*Colour of H_2O.*	*Temperature in °C.*	*Turbidity in cm.*	*Depth in ft.*	*Bottom.*	*Nature of bar.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
January ..	.. Clear	26	44	2–10	Sandy of clean sand.	Open.
February ..	.. Do.	30	42	2–9	..	Open artificially cut to prevent floods closed.
March ..	.. Do.	29	40	1–7	.	Closed.
April ..	.. Blackish	36	40	1–7	..	Do.
May ..	.. Greenish ..	35	34	1–7	..	Do.
June ..	.. Reddish	34	34	1–5	..	Do.
July ..	.. Blackish	30	36	1–6	..	Do.
August ..	.. Reddish	32	34	1–7	..	Do.
September	.. Greenish but clear.	31	35·3	1–8	..	Closed 29–31.
October ..	.. Muddy	29	37·5	2–9	..	Open.
November	.. Dirty	30	45	2–10	..	Do.
December ..	.. Blackish	28	45	2–10	..	Do.

TABLE B-1—B-IV

SECTION I—(AMINJIKARAI

Table

Month. (1)	*Green algae.* (2)	*Blue green algae.* (3)	*Diatoms.* (4)	*Desmids.* (5)
January	....	Coelosphoerium (∝)	Navicula (c) Melosira (f)	....
February	....	....	Synedra (c) Cyclotella (f)	Closterium (c) Gonotozygon (r) Cosmarium (f)
March	....	Coelosphoerium (∝)	Synedra (c)	....
April	Ankistrodesmus Pleurococcus,	....	Navicula	Mesotaenium Netrium
May	Do.	....	Do.	Do.
June	....	Coelosphoerium	Do. Melosira	....
July	....	Coelosphoerium (c)	Melosira (c)	....
August	Pediastrium (c)	....	....	....
September	Do.	....	....	....
October	Do.	Coelosphoerium (c)	Navicula (c) Melosira (c)	Mesotaenium (c) Netrium (c)
November	....	....	......	....
December	....	....	Navicula (r) Melosira (r)	....

SECTION II

Table

Month. (1)	*Green algae.* (2)	*Blue green algae.* (3)	*Diatoms.* (4)	*Desmids.* (5)
January	Tetraspora (r). Spirogyra (f).	Coelosphoerium (c).	....	....
February	Pleurococcus (f).	....	Synedra (f). Fragillaria (c)	
March	Spirogyra. Tetraspara.	Coelosphoerium (c).	....	....
April	Ophiocytium. Spirogyra. Ankistrodesmus.	....	Navicula.	Closterium.
May	Ankistrodesmus. Pleurococcus. Spirogyra. Ophiocytium.	....	Do.	Closterium. Netrium.
June	Tetraspora (c) Spirogyra (c)	Coelosphoerium (c).	....	....
July	Do.	Do.	....	....
August	Spirogyra (f). Microspora (c). Ulothrix.	....	....	Closterium (c). Netrium (c).
September	Spirogyra (c). Microspora (c) Ulothrix (c)	....	....	Closterium (c). Netrium (c)
October	....	....	Navicula (c).	Netrium (f) Closterium (f)
November	....	....	....	Cosmarium (c)
December	Spirogyra (r). Microspora (r). Ulothrix (r).	....	Navicula (c).	....

(∝) Indicates numerous.
(c) Indicates common.

(f) Indicates few.
(r) Indicates rare.

—PLANKTON.

BRIDGE).

B–I.

—	*Rotifers.* (6)	*Euglena.* (7)	*Daphnids.* (8)	*Nauplius.* (9)
January	Salpina (f) Rotifers (r)	....	....	3–5
February	....	....	....	Bar closed—*Tilapia* caught in trial netting. Megalops in 1 section. 2–5
March	Salpina (c) Rotifers (r)	....	....	3–4
April	....	....	....	3–5
May	....	....	....	3–5
June	Rotifers Salpina	....	....	3–5
July	Rotifers (c) Salpina (c)	....	....	3–4
August	Rotifers (c) Salpina (c)	(f)	Macrothrix (∝) Sida (∝) Daphnia (∝)	C-Nauplius and other crustacean larvae. 5–8
September	Do.	(f)	Do.	C-Nauplius and other crustacean larvae (c). 5–5
October	....	....	....	4–4
November	Rotifers (f) Salpina (f)	....	....	1–1
December	Rotifers (r) Salpina (r)	....	....	Cypris (f) 3–3 38–54

(MUNRO BRIDGE).

B-II.

—	*Rotifiers.* (6)	*Copepods.* (7)	*Daphmids.* (8)	*Crustacean larvae.* (9)
January	....	....	....	....
February	Anuraea (r) Floscularia (f) *Polyarthra* (f) Dinocharis (r) Gastropus (f)	....	....	*Nauplius larva.*
March	....	....	....	....
April	....	....	....	....
May	....	Cyclops.	....	....
June	....	....	....	....
July	....	....	....	....
August	....	Cyclops (c)	Macrothrix (f)	Nauplius larvae (c)
September	....	Do. (s)	....	Do.
October	Gastropus (c)	Do. (c)	....	Do.
November	Do. (f)	....	....	Do.
December	Do. (∝)	....	....	....

(∝) Indicates numerous.
(c) Indicates common.

(f) Indicates few.
(r) Indicates rare.

SECTION III (ST.

Table

Month. (1)	*Green algae.* (2)	*Blue green algae.* (2)	*Diatoms.* (4)	*Desmids.* (5)
January	Ankistrodesmus (c) Pleurococus (f).	Coelosphoerium	Navicula (f)	Cosmarium (f)
February	Ankistrodesmus (r) Tetraspora (c)	Phormidium (c)	Navicula (f) Synedra (c)	....
March	Green algae (c)	Do. (∝)	Do. (f)	Do. (r)
April	....	Do. (∝)	Do. (c)	Do. (c)
May	....	Do. (∝)	Do. (f)	Do. (r)
June	....	....	Do. (f)	Do. (f)
July	Do. (f)	Do. (f)	Do. (c)	Do. (c)
August	....	....	....	....
September	....	....	....	....
October	....	Do. (c)	Do. (c)	Do. (c)
November	....	Oscillatoria (c) Microcystis (c).	....	Cosmarium (c) Penium. (c) Cyclotella. (c)
December	....	....	Do. (c)	....

SECTION IV

Table

Month. (1)	*Green algae.* (2)	*Blue green algae.* (3)	*Diatoms.* (4)	*Desmids.* (5)
January	....	Phormidium. Coelosphoerium. Nostoc (f).	Navicula (c)	Netrium (r) Penium. (r) Cosmarium (f)
February	Ophiocytium (c) Dictyosphoerium (f)	Spirulina (c). Coelosphoerium (r).	....	....
March	....	Do. (c)	Do. (f)	Do. (f)
April	Ankistrodesmus. Dictyosphoerium. Pleurococcus.	....	Navicula.	Gonatozygon. Netrium. Mesotaenium.
May	....	Do. (c)	Do. (c)	Do. (c)
June	....	Do. (c)	Do. (f)	Do. (c)
July	Do. (c)	....	Do. (c)	Do. (c)
August	Plankton richer in crustacean larvae than previous month.		Do. (c)	Do. (c)
September	....	....	Do. (c)	Do. (c)
October	Do. (f)	....	Do. (c)	Do. (c)
November	....	Nostoc (c).	Do. (f)	....
December	Do. (c)	....	Do. (c)	....

Andrew's Bridge).

B-III.

Month.	*Rotifers.* (6)	*Cyclops.* (7)	*Daphnids.* (8)	*Nauplius larvae Pandorina, lv ox.* (9)
January	....	....	....	....
February	Dinocharis (r) Gastropus (f).	....	....	....
March..	....	....	....	....
April	....	....	....	....
May	....	....	....	....
June	....	....	....	....
July	....	....	....	....
August	....	(∝)	(∝)	....
September	....	(∝)	(∝)	....
October	Do. (c)	(c)	....	Pandorina. Volvox. Colonial ciliates (∝) Nauplius.
November	....	....	....	Do. (f)
December	Do. (c)	....	....	Carchesium. Colonial ciliates.

(Napier Bridge).

B.IV.

Month.	*Rotifers.* (6)	*Cyclops.* (7)	*Daphnids.* (8)	*Bar.* (9)
January	Dinocharis (f).	....	....	Partially open.
February	Frustulla (f). Suriella(r) Cyclotella (r).	....	Macrothrix (f)	....
March	Do. (c)	....	....	Plankton as dense as in February in the river.
April	....	....	....	....
May	....	....	....	....
June	....	....	....	....
July	....	....	....	Plankton rich—bar closed.
August	....	(∝)	....	Bar closed First 11 section water was dirty and smelly. ....
September	....	(c)	....	
October	....	....	....	Nauplius larvae (f)
November	....	(f)	....	....
December	Do. (c)	....	Flagellates.	....

Tables C-1 to

SECTION I—

Table

Month. (1)	*Murrel.* (2)	*Cat-fish.* (3)	*Prawns.* (4)	*Glossogobius.* (5)	*Tila pia.* (6)
January	Murrel	Cat-fish	P. indicus	....	..
February	....	....	Do.	....	..
March	....	....	Do.	Glossogobius ..	..
April	....	....	Prawns	....	..
May	O. punctatus ..	Cat-fish ..	Do.	Gobius	..
June	Do. ..	..	Do.	....	..
July	....	Cat-fish ..	Do.	Gobius	Tilapia.
August	....	..	Do.	Mastcaembalus ..	..
September	....	..	..	Glossogobius ..	..
October	No	Fish	was	netted	
November	O. punctatus ..	..	Prawns	....	..
December	O. striatus	Cat-fish ..	..	....	..

SECTION II—

Table

Month. (1)	*Murrels.* (2)	*Cat-fish.* (3)	*Prawns.* (4)	*Chanos.* (5)	*Discognathus.* (6)
January	O. striatus	..	Metapenaeus monoceros.		..
February	....	....	Do.	....	....
March	....	Mastacembalus and Cat-fishes.	Do.	Chanos	....
April	....	....	Prawns	....	....
May	O. punctatus ..	....	Do.	....	....
June	Do. ..	....	Do.	....	....
July	....	....	....	....	....
August	....	....	....	....	Discognathus.
September	....	....	Prawns	....	....
October	....	....	Do.	....	....
November	O. punctatus ..	....	Do.	....	....
December	O. striatus	Cat-fish	Prawns, Palaemon Lamarrei and Metapenaeus monoceros occur in this section of the river.	....	....

C-4 Fishery.

(Aminjikarai).

C-I.

Month.	*Megalops.* (7)	*Mullets.* (8)	*B. stigma.* (9)	*E. maculatus.* (10)	*P.M. fishes.* (11)
January	....	....	..	E. maculatus ..	..
February	Megalops	....	B. stigma	....	..
March	....	Mullets	B. stigma and B. ticto.	E. maculatus ..	Chela, Nuria and Rasbora.
April	....	....	Barbus	Do. ..	....
May	....	....	Do.	....	....
June	....	....	..	....	Chela and Labuca.
July	....	....	B. stigma	....	Nuria.
August	....	....	Do.	....	Rasbora and Amblypharyngodon.
September	....	....	Barbus and Rasbora.	....	....
October	....	....	.... ..	....	....
November	....	....	Barbus	...	Chela.
December	....	....	Do.	....	Lasbuca and Trichogaster.

(Chetput Bridge).

C-II.

Month.	*Glossogobius.* (7)	*Megalops.* (8)	*Mullets.* (9)	*B. stigma.* (10)	*E. maculatus.* (11)	*P.H. fishes.* (12)
January	Glossogobius	....	....	....	....	....
February	....	....	....	....	....	Labuca, Loaches Nuria.
March	Glossogobius	....	Mullets ..	B. stigma ..	....	Rasbora, Amblypharyngodon. Trichogaster. Chela.
April	Gobius	....	....	..	....	
May	..	....	....	Barbus ..	....	....
June	Gobius ..	—..	....	Do. ..	....	Chela.
July	....	....	....	....	E. maculatus.	Do.
August	....	....	....	....	....	Nuria.
September	....	....	....	Barbus ..	....	....
October	....	....	....	Do. ..	....	....
November	....	Megalops	....	Do. ..	....	....
December	....	Do.	....	Do. ..	....	....

SECTION III—

Table

Month. (1)	*Cat fish.* (2)	*Prawns.* (3)	*Diagramma.* (4)	*Megalops.* (5)	*Mullets.* (6)
January	....	P. monodon	Diagramma ..	....	....
February	....	....	....	....	....
March	....	P. monodon	Diagramma ..	....	....
April	....	....	....	....	....
May	....	....	....	....	....
June	....	Prawns ..	....	....	....
July	....	....	....	Megalops	....
August	....	....	....	Do.	....
September	....	....	....	Do.	....
October	....	Prawns ..	....	..	....
November	....	Do. ..	....	..	Mullets (Fry).
December	Cat-fish..	Prawns, Metapenaeus monoceros P. monodon.	....	Megalops	....

SECTION IV—

Table

Month. (1)	*Cat fish.* (2)	*Prawns.* (3)	*Sillago.* (4)	*Glosso gobius.* (5)	*Leiognathus.* (6)
January	....	..	Sillago.	Glossogobius	L. sp.
February	....	P. monodon	....	....	Neuyuveti.
March	....	Prawns ..	....	....	....
April		No fish collected during trial nettings.			....
May	....	Prawns ..	....	Gobius Ooden.	....
June		Nil in trial nettings.			
July		Do.			
August		Do.			
September		No fishes in trial nettings.			
October		Do.			
November	....	Prawns....	....	....	....
December	Cat-fish ..	Prawns and P. monodon.	Sillago ..	....	....

1. B. sp. is the only variety of P.H. fish collected from the section.

(CHINTADRIPET BRIDGE).

C-III.

Month.	*Eqlulna.*	*B. stigma.*	*E. maculatus.*	*P.H. Fishes.*
	(7)	(8)	(9)	(10)
January	....	....	....	....
February	Equulla	....	....	....
March	....	....	....	Gambusia.
April	....	....	....	....
May	....	....	....	Gambusia.
June	....	....	....	Do.
July	....	B. stigma	....	....
August	....	....	....	Gambusia.
September	....	....	....	....
October	....	B. stigma ..	....	....
November	....	....	....	....
December	....	....	....	....

(NAPIER BRIDGE).

C-IV.

Month.	*T. jarbua.*	*Lutjanus.*	*Mullets.*	*B. stigma.*
	(7)	(8)	(9)	(10)
January	....	Lutjanus sp.	....	....
February	....	....	Mullets	....
March	Therapon jarbua ..	....	Do.	....
April	No fish collected during trial nettings.			
May	....	....	....	....
June		Nil in trial nettings.	....	....
July		Do.	....	....
August		Do.	....	....
September		Do.	....	....
October		Do.	....	....
November	....	....	....	Barbus sp.
December	....	....	....	Barbus.

2. Gambusia are said to be collected.

TABLES D1 to D4.

Fishery, kind of craft and catch effort.

SECTION I.

Table D-1.

Month.	*Fishery.*	*Number of fishermen.*	*Kind of tackle.* Cast net.	*Kind of tackle.* Rod and line.	*Kind of tackle.* Katcha Enthuvalai.	*Catch effort.*	*Total monthly landings.*	*Daily earning per fisherman.*	*Total value of fish exploited.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
						LB.	LB.	RS. nP.	RS. nP.
January ..	Murrels .. .. .. Cat fish .. .. Prawns .. .. .. E. maculatus .. .. Therapon	5	X	..	..	6	930	2 00	310 00
February ..	Prawns .. .. .. Megalops .. .. B. stigma	5	X	..	..	6	930	2 00	350 00
March	P. indicus .. .. Mullets .. .. .. B. ticto .. .. .. Glossogobius .. .. B. stigma .. .. Chela .. .. .. Nuria .. .. .. Rasbora .. .. .. O. punctatus, etc. ..	6	X	..	..	6·10	1,860	3 00	558 00
April	Barbus .. .. .. Prawns .. .. .. E. maculatus .. .. O. punctatus .. .. Gobies, etc.	8	X	X	..	4·8	1,680	3 00	620 00
May	O. punctatus .. .. Prawn .. .. .. Gobies .. .. .. Barbus	13	X	X	..	5·10	4,030	3 50	1,410 50
June	Megalops .. .. O. punctatus .. .. Prawns, etc.	7	X	..	..	5	1,050	1 00	315 00
July	Cat fish .. .. .. Prawns .. .. .. Gobies .. .. .. P. H. fishes	5	X	..	..	3	465	1 00	155 00
August	Prawns .. .. .. Mastacembalus .. .. B. stigma	5	X	..	..	2	310	1 00	155 00
September ..	Glossogobius .. .. Misc. variety .. .. Barbus .. .. .. Rasbora, etc.	5	X	..	..	2	300	1 00	150 00
October	....	No landings from this station.							
November ..	O. punctatus .. .. Prawns .. .. .. Chela .. .. .. Barbus, etc.	12	..	..	..	6	2,160	2 00	720 00
December ..	O. striatus .. .. Cat fish	10	X	X	..	4	1,240	2 00	620 00
	Total ..	81					14,955		5,363 00

X indicates kind of craft used in this section.

.. indicates Nil.

SECTION II (CHETPET).

Table D-II.

Month.	Fishery.	Number of fishermen.	Kind of tackle: Cast net.	Kind of tackle: Rod and line.	Kind of tackle: Katcha Enthuvalai.	Catch effort.	Total monthly landings.	Daily earning per fisherman.	Total value of fish exploited.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
						LB.	LB.	RS. NP.	RS. NP.
January ..	O. striatus .. .. Prawns .. .. .. Lobsters .. .. .. Glossogobius	9	X	..	..	6	1,674	2 00	558 00
February ..	Prawns .. .. .. P.H. fishes	9	X	..	..	6	1,512	2 00	630 00
March	Mastacembelus .. Cat fish .. .. .. Prawns .. .. .. Chanos .. .. .. Mullets .. .. .. P.H. fishes, etc. ..	9	X	..	..	8	2,232	3 00	837 00
April	Prawns .. .. .. Gobius .. .. .. Chela	6	X	..	..	5	900	2 00	360 00
May	O. punctatus .. .. Prawns, etc.	5	X	..	..	7	1,085	3 00	455 00
June	O. punctatus .. .. Prawns .. .. .. Gobius .. .. .. Chela .. .. .. Barbus, etc.	7	X	..	..	3	630	1 00	315 00
July	Cat fish .. .. P. H. fishes	9	X	..	..	5	1,335	2 00	558 00
August	Mullets .. .. .. Prawns .. .. .. Discognathus .. .. P. H. fishes	8	X	..	..	5	1,240	2 00	496 00
September ..	Prawns .. .. .. Megalops .. .. Barbus, sp.	5	X	..	..	4	500	2 00	300 00
October	Prawns .. .. .. Barbus .. .. .. Gambusia	5	..	..	X	2	310	0 75	116 25
November ..	O. punctatus .. .. Prawns .. .. .. Megalops .. .. Barbus	12	X	..	X	6	2,160	3 00	1,086 00
December ..	O. straiatus .. .. Prawns .. .. .. Lobsters .. .. .. Cat fish .. .. .. Megalops	11	X	X	..	3	1,023	1 00	511 50
	Total ..	93					14,761		6,226 75

X indicates kind of craft used in this section,
.. indicates Nil,

SECTION III —(CHINTADRIPET).

Table III.

Month.	*Fishery.*	*Number of fishermen.*	*Kind of tackle* — *Cast net.*	*Rod and line.*	*Katcha Enthuvalai.*	*Catch effort.*	*Total monthly landings.*	*Daily earning per fisherman.*	*Total value of fish exploited.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
						LB.	LB.	RS. NP.	RS. NP.
January ..	Prawns .. .. .. Diagramma, sp. ..	9	..	..	X	5	1,395	2 00	558 00
February ..	Equulla .. .. .. Other Misc. Varieties	4	..	..	X	3	336	1 00	112 00
March ..	Prawns .. .. .. Diagramma .. .. Megalops .. .. Gambusia	2	..	..	X	4	248	1 50	93 00
April ..	Megalops .. .. Gobius, etc.	4	..	..	X	4	480	1 75	210 00
May ..	Megalops .. .. Gobius .. .. .. Gambusia	4	..	..	X	3	372	1 00	124 00
June ..	Megalops .. .. Gobius .. .. .. Prawns	2	..	..	X	3	180	1 50	90 00
July ..	Megalops	10	..	..	X	10	3,100	5 00	1,550 00
August ..	Megalops .. .. Mullets	8	..	..	X	8	1,984	4 00	992 00
September ..	Megalops	9	..	..	X	5	1,395	2 50	675 00
October ..	....				Nil.				
November ..	Prawns .. .. .. Mullets (fry)	50	..	X	X	8	12,000	2 00	3,000 00
December ..	Cat fish .. .. Prawns .. .. .. Megalops	3	..	X	X	3	279	1 00	93 00
	Total ..	105					21,769		7,297 00

X—Indicates kind of craft used in this section.
..—Indicates Nil.

SECTION IV (IRON BRIDGE).

Table IV-B.

Month.	*Fishery.*	*Number of fishermen.*	*Kind of tackle* Cast net.	*Kind of tackle* Rod and line.	*Kind of tackle* Katcha Enthuvalai.	*Catch effort.*	*Total monthly landings.*	*Daily earning per fisherman.*	*Total value of fish exploited.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
						LB.	LB.	RS. NP.	RS. NP.
January ..	Mullets, Sillago, Glossogobius, Leiognathus, Lutjanus	15	X	..	..	7	131	2 00	1,162 50
February ..	Prawns, Mullets, Diagramma	3	X	..	..	4	336	1 50	125 00
March ..	Prawns, Mullets, Equulla, Gobies, Sillago	15	X	..	..	10	4,650	3 00	1,743 75
April ..	Prawns, Mullets, Equulla, Gobies, Sillago	3	X	..	..	3	270	0 12	100 08
May ..	Prawns, Gobies	9	X	X	..	5	1,395	2 00	588 00
June ..	Mullets, Prawns	10	..	..	X	3	900	1 00	300 00
July ..	Megalops, Mullets	9	..	..	X	5	1,395	2 50	697 50
August ..	Megalops, Mullets	8	..	..	X	6	1,488	3 00	744 00
September ..	Megalops, Prawns	4	..	..	X	5	600	2 50	300 00
October ..	....			(No fisherman).					
November ..	....			Do.					
December ..	Cat fishes, Prawns	4	X	..	X	3	360	1 50	180 00
	Total ..								

X—Indicates kind of craft used in this section.

..—Indicates Nil.

A NOTE ON THE HYDROLOGY OF BHAVANISAGAR RESERVOIR FOR THE YEARS 1956-1961.

BY

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Though excellent accounts of the Limnology of the American, European and African lakes are available, very little is known about the tropical impoundments and of the man-made lakes—Hutchinson's type 73. A summary of the Hydrological data obtained for the Bhavanisagar Reservoir, Madras State, is presented herein.

The Bhavanisagar reservoir has been formed by the construction of a dam below the confluence of the two rivers, Bhavani and Moyar both coming down the Nilgiri Hills. The area of the reservoir is 30·4 square miles, the volume of water impounded being 28,000 m.c.ft. The maximum depth is 100 ft. (33 m.). The data presented in Table I shows the annual variations in temperature, pH value and dissolved oxygen content of the surface and bottom waters of the reservoir proper and of the portions Bhavani and Moyar.

The annual variations in the temperature of water was very little especially in the reservoir but a large difference was noted (11·8°c) in Moyar in 1961. It was in 1961 that the lowest temperature was reached, *viz.*, 21·2°c in Moyar. An important feature continuously noted in the reservoir (which is not obvious from Table I) is the absence of a stable thermal stratification in fact there was none at all. Among other causes such as higher penetration of light, air temperature, etc., the absence of stratification may also be due to the fact that the hypolimnetic waters are discharged by the intakes that discharge water into the Canal and the river. The temperature curves for surface and bottom waters are very close to each other. The maximum surface temperature was reached in April–May following the air temperature to some extent, but the lowest temperature of surface water was not attained in December–January in parallel with air temperature, but in July–August following the floods in rivers (except in 1961). Since, the two rivers flow down from the hills with lower temperature, they influence the thermal structure of the reservoir much more than does the air temperature. The surface temperature of the waters was always less than the air temperature.

Except for one month, Phenotphthalein alkalinity was invariably absent in 1956 even in surface waters and free carbondioxide was present. A pH value above 8·2 was reached only once during the period when free carbondioxide was absent. A very high pH value of 9·1 was reached in 1957 in Bhavani concomitant with oxygen super saturation over 100 per cent for a brief period in December. By 1958 oxygen, supersaturation was noted for brief period in the surface waters, with a high pH value reaching 8·9. Alkalinity in the surface waters and even in bottom waters became more evident. Oxygen saturation progressively increased in 1959 and in 1960 it exceeded 200 per cent, in surface waters and even the bottom waters were supersaturated. However Hypolimnial oxygen deficit occurred in the Reservoir and Bhavani in March and May of 1960. The high oxygen super saturation was followed by the appearance of nitrate in the reservoir and Bhavani waters—for the first time in five years. A comparison of Dorairajah's data (1956) for the surface water of the reservoir in 1954, shows the progressive increase in pH, oxygen concentration and alkalinity since then. From the data furnished, it could be seen that the dissolved oxygen of surface waters was never a limiting factor for fish, since oxygen saturation was well above the limits prescribed.

The gradual warming up of the waters from 1956 to 1961 is evident from Table No. I.

Silicate content did not appear to be influenced by the floods and varied from 2·0 to 12·0 p.p.m. Inorganic phosphate has not so far been detected in these waters. Many authors have mentioned that the high phosphate content of coastal waters of the seas during floods was due to influx of river waters carrying large amounts of phosphates. However, even during floods, neither Bhavani nor Moyar carried any detectable amount of phosphate. A survey of the distributaries of the rivers Cauvery and Coleroon for one year (unpubl. results) also failed to indicate detectable quantities of phosphates at any time of the year. At least under our conditions, phosphates are not contributed by the rivers to inshore seas. This confirms the views of Rao and George. Nitrate estimation taken up since November 1961 indicated the presence of nitrate in the bottom water of the reservoir in December and also in surface water of river Bhavani. The electrical conductivity of the reservoir water was found to increase with depth confirming the observations of Edmondson (1953).

A study of the reservoir soil indicated a high ammonia between December and April. This is mostly due to decomposition of nitrogenous matter. Since nitrates were detected during December and May, the inference is that ammonia gets oxidized. The soil had a higher available phosphorus in July-August but this was never reflected in the water at any time.

Detailed account of this work will be published elsewhere.

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TABLE I.

Range of Certain Hydrological Factors in the Bhavanisagar Reservoir and the Rivers Bhavani and Moyar for the Year 1956–61.

Year.		*Temperature °C.*			pH			*Dissolved oxygen mg./L.*		
		Bhavani.	*Reservoir.*	*Moyar.*	*Bhavani.*	*Reservoir.*	*Moyar.*	*Bhavani.*	*Reservoir.*	*Moyar.*
1956 ..	S	23·7—30·8	23·8—29·3	24·8—30·2	7·1—8·4	7·1—8·7	7·2—8·5	2·0—8·0	3·0—7·9	2·5—8·2
	B	22·5—28·4	23·2—28·1	23·1—28·1	6·6—8·3	6·7—7·0	6·8—8·4	0·0—7·0	0·0—6·1	0·0—6·0
1957 ..	S	26·3—29·6	27·2—29·4	25·6—29·8	7·3—9·1	7·6—8·9	0—8·9	2·3—8·5	4·5—6·8	4·4—7·6
	B	25·2—27·3	25·2—27·4	25·0—27·1	6·5—8·0	6·5—8·0	6·7—8·5	0·7—5·9	0·2—3·7	0·4—5·8
1958 ..	S	26·5—30·7	26·8—30·8	26·4—30·3	7·5—8·9	7·4—8·9	7·4—8·8	4·9—8·4	5·0—9·1	4·3—8·4
	B	24·8—29·6	25·0—30·0	25·2—29·6	6·9—8·0	6·6—8·2	6·8—8·1	0·3—5·9	0·2—6·8	0·0—6·5
1959 ..	S	28·0—30·0	27·8—30·2	27·8—30·2	8·0—8·8	8·2—8·7	7·2—8·7	5·0—15·1	2·7—12·9	5·5—12·9
1960 ..	S	27·0—30·8	26·4—31·0	26·8—31·0	7·9—8·8	8·0—8·7	8·1—8·7	6·2—21·0	4·4—20·0	4·8—19·8
	B	24·4—29·4	24·0—29·4	24·0—29·2	6·8—7·6	6·7—7·6	6·7—8·5	0·0—14·0	0·0—12·0	0·1—10·2
1961 ..	S	21·9—31·8	24·1—31·0	21·2—33·0	7·5—8·5	7·4—8·7	6·7—8·7	5·6—7.8	5·2—9·1	4·6—9·0
	B	..	22·3—30·2	..	..	6·9—7·9	..	..	0·0—8·0	..

S = Surface. B = Bottom.

A NOTE ON THE USE OF AUREOMYCIN AS GROWTH PROMOTOR FOR FISH.

BY

A. SREENIVASAN, HYDROLOGIST, BHAVANISAGAR.

Artificial feeding of fish assumes importance in pond fish culture, as well as in hatcheries and nurseries. In trout hatcheries, artificial mixture of food is used to increase growth as well as "condition" of fish (1–3). However, these costly mixtures, though used in foreign countries, cannot be made use of in our country. Cheaper proteinaceous feeds such as oil seed cakes are available in plenty and it should be possible to make use of them. One of our problems in fish culture is lack of suitable *nursery sites to rear fry* into fingerlings, stage before stocking in cultivable waters. To this end any growth promoting substance will be useful.

The *work of the Lederle Scientists (Stocksted 1954*, Jukes and William 1953) had shown that many of the fungal antibiotics had growth promoting effect on poultry, ruminants and also on children. Hence, it was thought desirable to study the effect of aureomycin supplements on the growth of young fish.

. Fish were kept in cement cisterns of size 120 by 100 by 70 cms. with soil substratum. Three sets were used, one control subsisting only on the natural plankton and insects, larvae, etc. a second cistern having fish to which a daily addition of groundnut cake was added and a third receiving the same amount of groundnut cake as well as aureomycin in the form of 'aurofac', a product of Lederle laboratory containing 1·8g. of aureomycin and 1·8 mg. Vitamin–B12 *per* pound. *After 30 days the fish were* netted out, weighed and their length measured. Initial weight and size of fish were recorded.

The results of experiments are presented in Table I. The growth was calculated as per cent increment in growth i.e., $\frac{\text{Weight in 30 days} \times 100}{\text{Initial weight.}}$

The efficacy of feeding was also judged by 'food conversion ratio' i.e., the amount of feed required to produce one Unit weight of growth in fish. The lower this ratio, the more efficacious the food. It is seen that aureomycin supplemented diet showed consistently good results. Addition of aureomycin produces more fish flesh for the same amount of good stuff such as oil seed cakes. It has got the 'food sparing' effect i.e., smaller quantities of food could produce the same amount of growth when aureomycin *is added to the rations.*

The importance of growth stimulants lies in the fact that in pond fish culture. fattening of fish for the table is an *important process. Likewise in raising fingerlings from* fry also, there will be shortening of time by the use of aureomycin. Economy in food is also achieved.

The author wishes to thank Messrs. Lederle Laboratories Bombay, for the gift of 'aurofac' for these experiments. The assistance of Shri M. V. Natarajan is also acknowledged.

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TABLE I.

Experiment number.	*Fish used.*	*Initial size cms.*	*Percentage increase in growth for each month.*			*Food conversion ratio.*	
			Control.	*Groundnut cake 10·0. g.*	*Groundnut cake 10·0 g. plus 'aurofac' 1·0 g.*	*Groundnut cake.*	*Groundnut cake plus 'aurofac'.*
I Gourami	4 Nos.	4·7—5·2	7·0	233	500	17·1	8·8
				15·0 g.	15·0 g. + 1·5 g.		
II Gourami	4 Nos.	4·7—5·2	22·0	62·5	100	30·0	16·5
Tilapia	6 Nos.	7·5—11·2	16·0	88·0	120	10·5	16·5
				12·0 g.	12·0 g. + 1·2 g.		
III Gourami	5 Nos.	6·0—10·0	56·0	67·0	91·0	9·0	6·6
Tilapia	5 Nos.	4·8—9·5	22·0	80·0	85·0	9·0	7·2
				10·0 g.	10·0 g + 1·0 g.		
IV Gourami	5 Nos.	6·2—9·5	16·7	20·0	25·0	15·5	11·4
Tilapia	5 Nos.	6·6—10·0	20·0	80·0	116·7	10·3	4·9

A NOTE ON THE USE OF RANDIA DUMETORUM IN FISHERY MANAGEMENT

BY

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Pisciculturists would find wide application for substances that could be effectively and economically employed for the removal of unwanted fishes from Ponds and Lakes. Derris and its various formulations find wide use in fishery management.

Though a number of substances from plants like *Bassia lalifolia*. *Herium sdorum Acacia inlica* and *Randia dumetorum* are reported as toxic to fish. No systematic work has been done on the use of any of these substances. Hence an attempt was made to study in detail the toxicity of *Randia dumetorum*, to some fresh water fishes.

Randia dumetorum locally known as "Karaikkal" and "Madukkarai" in Tamil is available in large quantities in our forests of East Coast districts. This is commonly used for poisoning stagnant pools in the rivers for easy and wholesale illeged capture of fishes. Use of fish poisons, though prohibited by law is still in vogue to a small extent. Though it is reported that all parts of the plant could be used as fish toxicant only the seeds of *Randia dumetorum* in the powdered form were used in our experiments.

Toxicity tests were made in aquaria Jars of 15 litre capacity and in cement cisterns of 600 litres capacity. Five species of fish were used in the tests. The fishes used were *Cirrhina*, *Labeo*, *Barbus*, *Danio* and *Ophiocephalus* species, of 30 to 130 mm size. All fishes were well conditioned after capture in cement cisterns for 24 to 48 hours and only fishes in healthy condition were used as test species. After filling the containers with known quantity of water, fishes were released and after an hour known concentrations of the powder of *Randia* seeds were added and mixed well. Observations were made periodically for 24 hours. The fishes reacted in the same way as they react to derris. They moved without balance clashing against the walls of the containers often before turning upside down and dying.

The temperature during experiments ranged between 26·6° C to 28·8°C while the pH varied from 6·6 to 7·4 and in one experiment it was 8·8. Free Carbondioxide was absent at times and when present it never exceeded 4·4 p.p.m. Bicarbonate content ranged between 32 to 67 p.p.m. Sufficient concentration of dissolved oxygen was maintained till the conclusion of experiments by bubbling in oxygen when it became necessary. Appropriate controls were maintained during the experiments.

The studies made revealed that the lethal concentration to effect 100 per cent mortality in 24 hours ranged between 20 to 25 p.p.m. As *Randia dumetorum* is found in fair quantities in our forests it could be employed in fishery management. However, since the dosage required to effect a total kill is fairly high it can have only a limited use.

Author's thanks are due to Shri A. Sreenivasan, Hydrologist for advice and for guidance in the preparation of this note.

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FISH CULTURE IN A SWAMP IN CHETPUT, MADRAS CITY.

BY

P. I. CHACKO AND MRS. J. G. ABRAHAM, MADRAS.

An extensive swamp, formed by the abandonment of a former brick-making field, is located in Chetput division in Madras city. The swamp was a source of mosquito-breeding. The Department of Fisheries took charge of it and attempted fish culture with satisfactory results as briefly recounted below:

The swamp has a water-spread area of 10 acres. Its depth ranges from 1 to 10 feet at different sections. It has overgrowth of vegetation like *Hydrilla Vallisernaria* and water lilies. Frogs, water snakes, tortoises-aquatic beetles and other insects and predatory fishes like *Ophicephalus striatus, O.punctatus, Anabas testudinens, Saccobranchus fossilis, Notopterus notopterus, and Macrones, cavasius* are common. Its plankton is represented by various forms like *Oscillatoria, Botryococcus, Anabaena, Cyclotella, Tetrapedia, Scenedesmus, Merismopedia Navicula, Aphanocapsa, Chlorcoccus, Euglena, Anuraea Schizocera, Diaptomus, Cyclops, Nauplius larvae, Daphnia, Bosmina, Diaphanosoma, Brachionus and Macrothrix.*

The range of physico-chemical conditions in the swamp are as follows:—

Conditions.	*Surface.*	*Bottom.*
(1)	(2)	(3)
Temperature, °C .. .	27.5—37.2	26.2—36.5
Turbidity, cm.	4.5—26.0	4.5—23.0
PH	6.8— 7.0	6.8— 7.8
Dissolved oxygen, cc/1 ..	1.60—4.82	0.70—4.63
Saturation, pp 1000,000.	29.0—87.0	12.6—78.0
Free carbondioxide ,	0.11—0·47	1.11—0.55
Bicarbonate ,,	7.99—20.8	8.3—20.8
Chlorides ,,	5.0—15.0	5.0—15·0
Silicates ,,	0.20—1.25	0.22—1.25
Phosphates	Traces	Traces
Nitrates	Nil.	Nil.

Periodical deweeding, elimination of predators and stocking seed of cultural species, resulted in progressive fish production as shown below:

Year.	*Total quantity of fish harvested in lbs.*	*Fish production per acre, in lbs.*
(1)	(2)	(3)
1955–56	1552¼	155.2
1956–57	2132½	213.2
1957–58	2644	264.0
1958–59	5124½	512.4
1959–60	6767¾	676.7
1960–61	6831¼	683.1

It may be seen that the production of fish is increased from 155·2 lbs. to 683·1 lb. per acre.

The landings of 6831¼ lb. made in 1960–61 comprised of

Tilapia mossambica	5601¾ lbs.
Catla catla	442½
Ophicephalus striatus	200½
Cirrhina reba	192½
Labeo fimbriatus	146½
Labeo rohita	111¾
Cyprinus carpio	83¼
Etroplus suratensis	30¼
Chanos chanos	8¼
Cirrhina cirrhosa	5
Notopterus notopterus	5
Mugil cephalus	4

About 82 per cent of the fishery is composed of *Tilapia.* It is apparent that Tilapia is suitable for culture in swampy waters containing predators like *Ophiocephalus* and *Notopterus.* The average size of Tilapia is 3–5 inches in length and 2 oz. in weight. The size attained by the other forms in the swamps ranged as follows:—

Name of fish.	*Length in inches.*	*Weight in lbs.*
(1)	(2)	(3)
Catla	12–14	2¼
Ophiocephalus striatus ..	10–24	½–4
Labeo fimbriatus	12–18	1–4
Chanos	6–9	¼–½
Labeo rohita	18–32	3–17½
Etroplus suratensis	4–6	8–3/16
Cirrhina reba	6–8	¼–½
Mugil cephalus	12–18	1–2
Cirrhina cirrhosa	12–18	1–4
Cyprinus carpio	12–26	3–16

This is a typical example of utilisation of an abandoned swamp for profitable fish culture. This fish farm has become popular among the citizens.

SURFACE PLANKTON OF THE PEARL BANK, THOLLAYIRAM PAR, OFF TUTICORIN.

BY

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Introduction.

The southern sector of the Gulf of Mannar off Tuticorin is rich in fisheries including those of pearl oysters and chanks. In the course of investigations on the hydrobiological conditions of this area, surface plankton from waters over the Thollayiram Par, the most productive pearl bank, was collected during the twelve months from April 1957 to March 1958. Observations on these collections are recorded in this paper. Mention may be made here of earlier work on the plankton and hydrography of the area by Chacko (1956, 1956 a, 1959), Chacko and Malu Pillay (1956, 1957), Chacko and Rajendran (1956, 1959), Chidambaram and Rajendran (1952) and Chidambaram, Rajendran and Valsan (1951).

Materials and Methods.

The Thollayiram Par extends within the 11 to 15 miles limit (18—24 kilometres) where the depth varies from 7 to 12 fathoms (14—22 metres). Surface hauls with a standard plankton net made out of Swiss bolting silk was made at about 9 a.m. once a week throughout the year. The net was towed from a motor launch for fifteen minutes. The collections were preserved in 5 per cent formalin and brought to the laboratory and analysed qualitatively and quantitatively. The volume of the collections were standardized to 1 litre, and a sub-sample of one c.c. was employed for numerical estimation of each organism. A graduated glass plate was used for spreading the sample and examining it under a binocular microscope. The total volume of plankton sediment was estimated by settling the entire collection in a conical glass sedimenter.

Distribution of Plankters.

Twenty important organisms were identified and studied as shown in the appended statement.

The plankton sedimentation ranged from 12 to 75 c.c. per litre. Plankton was poor from April to July and in October and December. It was abundant in August, September, November, and from July to March.

The diatoms, *Biddulphia*, *Chaetoceros*, *Coscinodiscus*, and *Rhizosolenia*, were present throughout the year except in October and February. Their total absence during these two months was noteworthy. *Biddulphia* was abundant in August and January. *Chaetoceros*, was common from June to September and *Coscinodiscus* in November. *Rhizosolenia* was swarming in September.

The blue green alga *Trichodesmium* swarmed in the area in the month of April, August and February. *Peridinium* was present in small numbers from June to September. The cystoflagellate, *Noctiluca* swarmed in September and was moderately present from October to December.

The Ctenophore, *Beroe* was abundant in April and May and was present sparsely from June to August and in December and January.

The Chaetognatha were well-represented by *Sagitta* throughout the year excepting in October. They were abundant in July, August and January. The rare and oceanic forms *Khronia* and *Spadella* were abundant in the area in the month of February and fairly common in the months of June and July. The occurrence of these rare and oceanic forms was noteworth–.

Among crustaceans, Copepods and their nauplii larvae were present throughout the year in large numbers.

The pelagic pteropod *Creseis* was abundant in August and in fair numbers in April, July, September, November, December and January.

Tunicates were represented by *Doliolum* in May, July, August and February and by *Salpa* in April only.

Eggs and larvae of fishes, particularly of *Clupeoids* and *Carangoids* were available in the plankton throughout the year.

Summary.

Twenty important organisms occured in the plankton over the pearl bank, Thollayiram par. These showed interesting fluctuations indicating the effect of oceanic conditions on the primary productivity of this section of the sea. The presence of fish eggs and larvae proved that the area is a good nursery for pelagic fishes.

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Statement showing numerical occurrence of twenty organisms in one litre of plankton over Thollayiram par.

—	*April.*	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A. Diatomeae—												
1. Biddulphia	1,000	..	6,000	13,000	28,000	4,000	..	..	17,500	50,000	..	5,000
2. Chaetoceros	1,000	2,500	20,700	13,000	16,300	14,000	..	..	16,000	5,000	..	5,000
3. Coscinodiscus ..	1,000	2,300	600	300	9,000	5,000	..	15,000	1,000	1,000	..	..
4. Rhizosolenia	2,000	..	2,600	13,200	8,000	70,000		..	..	..	..	..
B. Shizophyceae—												
5. Trichodesmium ..	23,000	12,600	..	..	36,000	..	..	..	..	..	..	..
C. Protozoa—												
6. Ceratium	..	4,300	2,600	3,600	..	5,000	9,000	7,000	2,300	2,300	..	600
7. Peridinium	..	..	300	300	4,000	400	..	..	..	..	..	..
8. Noctiluca	..	..	..	..	..	13,300	24,500	28,000	18,500	..	..	..
D. Coelenterata—												
9. Diphyes	6	4	10	6	6	112	2	..	..	..	..	..
E. Ctenophora—												
10. Beroe	1,000	1,200	7	6	316	..	..	..	50	52	..	..
F. Chaetognatha—												
11. Sagitta	29	38	69	554	389	171	..	5	27	351	42	82
12. Khronia and Spadella,	..	..	65	16	..	..	..	..		..	643	..
G. Crustacea—												
13. Copepods	2,000	11,100	5,000	35,000	16,000	13,000	25,000	23,000	7,000	8,000	13,000	27,000
14. Nauplii	500	7,000	1,000	2,500	2,000	13,000	4,000	500	300	300	600	14,000
15. Leucifer	..	17	..	333	..	..	130	1,000	46	630	47	19
H. Mollusca—												
16. Creseis..	48	..	..	49	7,500	19	..	17	170	410	..	..
I. Tunicata—												
17. Doliolum	6	3	..	15	59	..	..	..	..	..	15	..
18. Salpa	16	..	..	..	..	..	..	..	..	..	..	..
J. Pisces—												
19. Fish eggs	3	19	3	10	65	70	13	39	27	169	7	16
20. Fish larvae	3	1	23	20	11	14	10	69	31	13	5	8
Total plankton sediment (c.c.)	13	14	12	16	60	48	17	75	12	45	71	75

A SURVEY OF THE MARITIME METEOROLOGY AND PHYSICO-CHEMICAL CONDITIONS OF THE INDIAN PEARL BANKS OFF TUTICORIN IN THE GULF OF MANNAR FROM DECEMBER 1958 TO MAY 1959.

BY

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Introduction.

The Indian Pearl Banks of the Central Divisions of the Gulf of Mannar lie between 8°—55′ and 8°—20′ N. Latitude and 78°-10′ and 78-25′ E Longitude, corresponding with the productive pearl bank region on the opposite Ceylon Coast. Systematic information on the meteorology and hydrography of the pearl banks are not available except some random observations (Pearson, 1902), (Chidambaram etal, 1949) and (Chacko and Malu Pillay 1956 and 1957). A compresensive study of the physico-chemical conditions of the Indian Pearl Banks was possible during the underwater survey of these banks by Dr. F.B. Salvodor, Food and Agricultural Organization Expert, from December 1958 to May 1959. The results of this study are presented in this paper.

Materials and methods.

Samples of water from surface and bottom were collected from all the stations fixed by the survey team using Knudsen's reversible waterbottle. Temperature was determined with the help of Zambra and Negrette deep sea reversible thermometer of protected type. Standard apparatus were used and methods adopted for the major meteorological elements as described by Roy (1948) and for the physico-chemical conditions as detailed by Harvey (1945 and 1959) and Barnes (1957). Nitrate was estimated by the methods of Atkins (1935) using diphenyl benzdine and iron by the method of Cooper (1935) using 2:2 dipyridyl with the help of Klett Summerson Photo Electric Colorimeter, depth, nature of bottom, colour of water, visibility, current conditions of sea, temperature, specific gravity, pH, salinity, dissolved oxygen, excess base calcium, silicate–silicon, phosphate-phosphorus, nitrate—nitrogen and iron were determined and the result tabulated in Tables Nos. 1—6.

Maritime meteorology.

The region is exposed to both the South-West and North-East monsoons. But the North-east monsoon is the chief rain-bearing one. It sets in by the middle of October or early November and takes the course of North-West east and prevaills with full vigour till the end of February or early March. The South-West monsoon sets in after a period of transition by the beginning of May and lasts up to August or early September with peak in June-July. The total precipitation during April 1958 to March 1959 was 248·0 mm. of which 59·0 mm. of precipitation was from the South-West monsoon. February experienced a total rainfall of 99·0 mm. The atmosphere is generally dry throughout, and April to October may be said to be summer period and December to February, the winter period. During the period December 1958 to May 1959, the atmospheric temperature varied between 35·0 and 25·3° C. The monthly average temperature was between 26·9° C (in February) and 30·9 ° C (in May). Basing on the monthly averages, March, April and May may be termed as the hottest months and January and February the coldest. The atmosphere was very humid during December to February and humid conditions above 80 per cent were quite common during the period. North-east wind, set in early November, with an average speed of 11·0 KM/per hour prevailed till the end of March with speed ranging up to 30·0 KM/per hour and brought a total rainfall of 25·0 mm. till the end of April. The Tambaraparani river enters the Gulf near Pinnakayal almost at the centre of the Coastal line of the parts. The Vaipar and Vembar rivers fall on the north of the area.

Physico-chemical conditions.

The Physico-Chemical conditions of the pearl banks studied are given in Tables I to VI. The characters of each bank are as follows :—

(1) *Devi Par.*—The northern-most bank of this productive division of pearl banks lies south of Vaipar at 11.0 to 13.0 metres limit, the west and south-east regions being deeper. Bottom is flat, rocky, scattered over with fine sand. In the central and western regions sand is very little only to a height of 1 or 2 cms. but on the south-east, the sand covering is more up to 10-12 cms. On 31st January 1959, the water was green with visibility up to 10·0 metres and the current was from north to south. But in the middle of February, the water was coloured attractive blue and the visibility was reduced to 7·5 to 8·0 metres in the west and south-eastern regions although the current continued to be from north to south. Calm conditions prevailed during the entire period of study. The water was warm throughout and the surface temperature was 28·3°C on 31st January 1959 and bottom 27·6°C But in February, the surface temperature declined greatly probably due to the full away of the North-east monsoon and of the unusually high precipitation. Because of this cooling of the surface, in certain stations, surface temperature was slightly lower than the corresponding bottom temperature, the pH, was between 8·35 and 8·45 and in most of the stations, it was 8·40. Only in station SE 1 (surface), it was 8·10. The salinity was uniformly high in all the stations and was in the ascending trend. From 33·78°/oo on 31st January 1959, it rose up to 34·22/oo on 23rd February 1959. A regular vertical salinity gradient was observed in all the stations. According to Herdman (1902) pearl oyster lives in warmer and high saline water. The sudden

drop in salinity at surface in station No. SE 1 (25·27°/oo) is rather perplexing. The water was almost saturated with oxygen in January with higher concentration at the bottom. But during February, it was about 75 per cent saturated in the central northern and the western regions and still less in the other areas. The variation in excess base is suggestive of interesting biological activities at the surface as well as at the bottom. The water in the bank is generally rich in calcium and in other nutrients. Calcium concentration was normal *and the Ca/Cl ratio was between* 0·02194 and 0·02199 on 31st March 1959 as in the Tokyo Bay (Nisikawa, 1939). These values are comparable to those recorded by Kirk and Moberg (1933) from the English Channel, Matilda (1951) and Chow and Thomson in (1955). A sudden drop in the bottom at station N2 and a rise in the bottom at station W3 are noteworthy. Again the Ca/Cl ratio at SE 1 surface is suggestive of interesting biological phenomenon. The calcium concentration in the south-east region is very high and is far above the normal value. Values up to 0·02365 of Ca/Cl have been recorded as against the value of 0·22 of Nisikawa (1939) in Tokyo Bay. The water is very rich in silicate, phosphate, nitrate and iron and it is to be noted that the maximum concentration of silicate-silicon (14·30 gm. at /L), of phosphate-phosphorus (23·80 gm, at /L), of nitrate-nitrogen (4·25 g m. at/L) and of iron (10·2 gm. at/L) was recorded only in this bank and the surface as well as bottom waters at the "Central" station on 16th February 1959 exhibited the record concentration of phosphate, nitrate and iron. Starvation of the water for nitrate-nitrogen and iron have also been observed lately. It has been found by Venkataraman *et al* 1956 that the chemical composition of the meat of pearl oysters bearing big-sized pearls and seed-pearls and of meat of oysters without pearls are almost the same except for the iron content, being nearly 7 times in oysters without pearls than of meat with big pearls. It may be summarised that the pearl bank, Devi Par with warm and highly saline waters saturated with oxygen and very rich in essential nutrients like calcium, silicate, phosphate, nitrate and iron will serve as an ideal habitat of the Indian pearl oysters.

(2) *Pernando Par.*—It lies south of Devi Par at 11·0—11·5 metres limit. The bottom is flat, rocky with little sand in the southern region. The water is blue with a transparency of 5·0 meters. Calm conditions prevailed and only ripples were present. The current was from north to south. The water was warm and the temperature was between 27·4 *and 28·0°C. The surface water was slightly* cooler than the bottom at station E-2 and S-2. The pH was between 8·3 and 8·45. The salinity was high and was between 33·88 and 34·16°/oo the surface salinity being slightly higher than the bottom. The water was only 60 per cent saturated with oxygen. Calcium concentration was high and the calcium-chlorine ratio was between 0·0215 and 0·2249. The water is also rich in silicate, phosphate and nitrate. Concentration of iron was appreciable throughout. The par may be considered as a good pearl bank and is comparable to Devi Par.

(3) *Vai Par* (XV (*a*) and (*b*), dated 31st January 1959, in table II).—This is a fairly big bank lying SE of Devi par at 13·5 to 14·0 metre limit. The eastern region is slightly deeper. Bottom is rocky with sand and mud layer. In the *central region bottom is sandy with nullipores,* and madrepores in the eastern region. The visibility was 10·0 metres throughout. North to south current was in force. Calm conditions prevailed at sea. The water was coloured green on 31st January 1959 and was warm throughout. In the central region, the botttom was far warmer than the surface. Bottom recorded 28·9°C while the corresponding surface recorded only 27·7°C. The pH was between 8·40 and 8·45. Salinity was uniformly high between 33·87°/oo. A regular vertical salinity gradient was observed. The water was almost saturated with oxygen. The low concentration at the surface is suggestive of greater *utilisation of oxygen than production by the phyto*-planktons and other floral forms. The calcium concentration is slightly above normal and the Ca/Cl ratios were between 0·02197 and 0·02215 comparable to the value of 0·022 in Tokyo Bay (Nisikawa 1939). The water is also rich in silicate, phosphate, nitrate and iron. The condition of the water on this pearl bank may be considered ideal for the pearl oysters. But the sandy and muddy bottom presents a problem for the oysters to keep themselves attached.

(4) *Cruxian Par* (XIII *a*, dated 28th January 1959 in Table 2).—The par lies down south a little towards west of Devi Par at 12 metres limit with rocky bottom strewn with sand and small broken shells. The water was greenish with visibility of 10·0 metres and the southerly *current was in force. Sea was a bit rough and moderate* broad waves existed. The surface temperature was only 26·9°C and the bottom 27·0°C. pH was 8·5 throughout. Salinity was high but less than in the case of Devi Par and Vai Par. The water was about 80 per cent saturated with oxygen. Calcium concentration is slightly high, and the Ca/Cl ratio is comparable to the value of Nisikawa (1939) in Tokyo Bay. The water is rich in the other nutrients like silicate, phosphate, nitrate and iron. Except for a slight fall in temperature, the water may be termed as suitable for the Indian Pearl Oysters. Ca/Cl ratio is slightly less than that of Devi par.

(5) *Vantheevu Arupagum par* (XIII *b*.) dated 28th January 1959 in Table II).—Lies south-west of the Cruxian par at 12·0 metres limit. The bottom is rocky covered with sand. The water was coloured green with visibility of 10·0 metres. The surface temperature was only 27·0°C and the bottom 26·9°C and was cooler than Devi par, and Vai par, pH was between 8·45 and 8·50. Salinity was high but less than that of Devi par and Vai par. The water was about 80 per cent saturated with oxygen. Concentration of calcium was fairly high and the Ca/Cl ratio was 0·02209 *on the surface and 0·0229 at* the bottom. The water was rich in other nutrients like silicate, phosphate, nitrate and iron. The water of this bank compared with that of the Cruxian Par with a slightly better concentration of calcium. But the sandy bottom presents a problem.

(6) *Nagarai Par* (XIII *c*, dated 28th January 1959).—in table II This is a little *south-east of Vantheevu* Arupagum par at 12·5 metres limit with rocky bottom strewn with a little fine sand. The water was coloured green with a transparency of 10·0 metres. North to south current was in force. Moderate waves existed. Water was slightly warmer with temperature between 27·4°C and 27·2°C. pH ranged between 8·45 and 8·55. Salinity was 34·05°/oo at the surface and 33·4°/oo at the bottom, as in *the case of Cruxian par and Vantheevu Arupagum par.* The water was about 77 per cent saturated with oxygen, with higher concentration of oxygen at the bottom. The

water was very rich in silicate, phosphate, nitrate, and iron. Apart from the slightly low salinity of the water, the bank might be termed as an ideal bank for pearl oysters.

(7) *Utti Par* (Station II, dated 16th December 1958) in Table I.—Lies south of Nagarai par at 13 metres limit with flat rocky bottom with or without sand. Water was blue green with a transparency of 10·0 metres. Current was from N-S and the sea was rough and waves existed. Water was slightly warmer with temperature between 27·4°C and 27·0°C. pH was between 8·45 and 8·50. Salinity was between 32·13°/oo and 32·23°/oo. The low salinity might probably be due to the influx of fresh water due to rainfall. The water was super-saturated with Oxygen. Calcium concentration was high and Ca/Cl ratio was 0·02284 at the surface and 0·2251 at the bottom. The water was fairly rich in silicate, phosphate and nitrate. There was appreciable concentration of iron also. This bank might be considered as a good pearl bank.

(8) *Athompathu Par*.—Lies south-east of Utti par at 15 metres limit. The bottom was rocky with little sand and shell grit (XII-*a*, dated 27th January 1959 in Table II). The water was greenish blue with transparency of 14·0 metres. Current was from north to south. Sea was rough with high waves. The temperature was between 27·0 and 27·1°C, the bottom water being warmer. pH was 8·40 throughout. There was high saline water both at surface (33·11°/oo) and at the bottom (33·84°/oo) with about 90 per cent saturation of oxygen and high concentration of calcium. Ca/Cl ratio was 0·02273 at surface and 0·2215 at the bottom. The water was fairly rich in other nutrients, like silicate, phosphate, nitrate and iron. The conditions existed in this bank are favourable for the Indian pearl oyster.

(9) *Pasi Par* (XII-*c*, dated 27th January 1959 in Table II).—Lies south-west of Athompathu par at 16 metres limit. Bottom was rocky with sand, spread over it. The water was greenish blue with transparency of 14·5 metre The current was from north to south. Sea was rough with waves. Water was warmer at the bottom, and temperature was between 27·1°C and 27·4°C. Bottom water was highly saline (33·84°/oo) with a saturation of about 90 per cent of oxygen. Surface salinity was much less—only 32·94°/oo. calcium-chlorine ratio was 0·02195 at the surface and 0·02190 at the bottom. The water was also rich in other nutrients like silicate, phosphate, nitrates and iron. The condition of the water was favourable for the Indian pearl oysters though the sandy bottom is a hazard.

(10) *Pathrai Par* (XIII-*b*, dated 27th January 1959 in Table II).—Lies due west of Pasi par at 15 metres limit. Bottom is flat rocky with sand over it. Greenish blue water with a transparency of 14·0 metres. Current from north to south. Sea was rough with waves. Water was fairly warm (27·2°C) with a high salinity of 33·66°/oo at the bottom and 32·90°/oo at the surface and almost saturated with oxygen. The oxygen concentration of the bottom was slightly higher. The water was found rich in calcium the calcium-chlorine ratio being 0·02251 at the surface and 0·02226 at the bottom. It was also fairly rich in silicate, phosphate, nitrate and iron. But for the sandy bottom, the bank is suitable for the Indian pearl oyster.

(11) *Tholaiyaram Par*.—The biggest and most productive bank in the group lies almost south sast of Tuticorin and on the east, north-east and south-east of Athompathu Par at 14·0–22·0 metres limit. The northern and eastern regions are deeper.

Northern region (Stations NWE, 10-NWE 2 and W1-E7, dated 23rd March 1959 and 24th March 1959 in Table IV).—The region is deeper on the east —23 metres while the other area is between 20 and 21 metres. Bottom is flat rocky throughout with or without a little sand spread over it. Water is bluish with a transparency between 14·5 and 16·0 metres. Current was from south-north but was very weak. Calm conditions prevailed. Water was warm and the bottom temperature invariably above 28·70/°c surface water was slightly cooler than the bottom, except at the eastern end and the central portion, where the surface temperature of the region ranged between 27·7°C and 29·4°C, pH was between 8·35 and 8·45. Salinity was uniformly high and was above 34·50°/oo throughout. The regular vertical salinity gradient was observed in all the stations, except in station No. NW 2 where high saline surface-water and slightly less saline bottom water observed. The water was saturated up to 85 per cent with oxygen. The sudden variation in the excess base was suggestive of the interesting biological activities at the surface and bottom. Calcium concentration was far high and the ratio of calcium chlorine was invariably above 0·023, high calcium chlorine ratio of 0·0240 was also observed in this region. The concentration of the silicate and iron was also high. High iron content of 10·2 gm. at/L was also recorded in this region. (Station 'Central' bottom, dated 24th March 1959 in Table IV). The water was also rich in phosphate and nitrate.

The region with its very warm and high saline water saturated with oxygen and with very high concentration of calcium and rich nutrients, is ideal for the pearl oysters.

Northern Central (Station B0–B5 and C1–C11, dated 26th March 1959 and 30th March 1959).—The region was also deeper on the east, 22 to 25 metres. The other portion was between 19–20 metres. The bottom was rocky throughout. But on the eastern side and the western margin, the bottom is covered with sand. In the central region a little sand with shell grit was spread over. Water was bluish with a high transparency of 16 to 18 metres. Current was from north to south on 26th and from south to north on 30th. Calm conditions prevailed generally. The water was very warm especially at the bottom and the bottom temperature was invariably above 29·0°C. The temperature of the water varies between 28·4 and 29·6°C. The bottom was warmer throughout. pH was between 8·35 and 8·45. Salinity was very high between 34·62°/oo and 34·88°/oo. A regular vertical salinity gradient was observed in all the stations. Calcium was far high and the Calcium-chlorine ratio of 0·02590 of this region is a record. The water is very rich in silicate. Concentration of phosphate, nitrate and iron was also very appreciable. The conditions existed in the bank are very ideal for the Indian pearl oysters.

Central region (Stations D1–D7 and E0 4–E4, F1–F7, G1–G8 H1–H8, dated 2nd April 1959, 4th April 1959 and 7th April 1959 in Table V).—The region was 17·0 to 19·5 metres deep. The eastern border was 22·0 to 22·5 metres. bottom was flat rocky with sand, the sandy layer varying

between 2 to 25 c.m. in depth. Water was either greenish blue or bluish with poor transparency of 10 to 12 metres. The current was from south to north. Sea was slightly rough with waves. Water was very warm, especially at the bottom, temperature being 29·5–30·1°C. The surface was slightly less warm with a difference up to 1°C. pH was between 8·45 and 8·50 generally. The salinity was high and was between 34·28°/oo and 43·4°/oo, the salinity of the bottom being slightly higher invariably. The concentration of oxygen was a little less and saturation of oxygen varied between 60 per cent to 80 per cent. The calcium concentration was slightly less than in the northern central region. But the calcium-chlorine ratio was uniformly above the observed values of 0·022 of Nisikawa (1939). The water is very rich in silicate but the concentration of other nutrients like phosphate, nitrate and iron was very poor. The water was found to starve for nitrate and iron occasionally. But for the poverty of nutrients especially phosphate and nitrate and to some extent iron, the region may be said to be suitable for the pearl oysters, probably the poverty of nutrients will tell upon the rate of growth of the oysters. The high sandy layer on the eastern margin is not a favourable feature.

Southern Central (Stations I01–I5, J1–J7, dated 7th April 1959 and 13th April 1959 in Table V).—The central portion of the region was in 17–18 metres limit. The eastern side was slightly deeper and a depth upto 22·5 metres was recorded at station H7. The bottom was rocky throughout with sand over it. The height of the sand layer varied up to 25 c.m. Water was greenish or blue and the transparency was poor, between 10 and 11 metres. Water was very warm especially at the bottom, being invariably above 30·0°C. Surface temperature was slightly less, ranging between 29·3 and 30·2°C, pH was between 8·35 and 8·45. Salinity was uniformly high and was between 34·22 and 34·55°/oo. The surface salinity was slightly less. The saturation of oxygen was also less and was between 60 per cent to 80 per cent. Calcium concentration was less than in the northern region and the calcium chloride ratio between 0.02173 and 0·0220. The water was rich in silicate but phosphate, nitrate and iron were very poor; and even poverty conditions were observed very frequently. Although the water was warm and highly saline, the conditions on the bank did not appear to be favourable for the pearl oysters.

Southern Region (Stations K1–K10, L1–L9 and M1–M9, dated 17th April 1959 and 18th April 1959 in Table V).—The eastern portion was slightly deeper upto 20·5 metres and the other portions were between 16·0 to 18·0 metres. Bottom was rocky with up to 25 c.m. of sand. Shell grit was also found mixed with sand in certain station water was bluish and the transparency poor between 10·5 and 11·0 metres. Current was from south to north on 17th and from north to south on 18th. Swells existed. Water was very warm both at the surface and at the bottom, bottom water being slightly less warm. The temperature was between 30·4°C and 31·1°C, pH was between 8·40 and 8·50. Salinity was slightly higher than the southern central region and was between 34·40°/oo and 34·60°/oo. A regular vertical salinity gradient was observed throughout. Water was saturated up to 90 per cent with oxygen. The calcium concentration was also fair and the calcium-chlorine ratio was above 0·0220 invariably. The water was rich in nutrients in southern half; and poverty conditions of nitrate, phosphate and iron were observed in the northern half. But for the poverty of the nutrients and the high sandy layer at the bottom, the region might be considered as a very good pearl bank.

Koothadiar Par (Station No. V-*a*, *b*, dated 23rd December 1958 in Table I).—This is a small bank lying at the southern end of Thollayiram par at 16·0–17·0 metres limit with flat rocky and/rocky with sand bottom. Water was bluish with 10·0 metres of transparency. The current was from north to south and the sea was rough with waves. Bottom water was warm with 27·2°C and the surface slightly cooler with temperature between 26·75°C and 26·55°C on 23rd December 1958, pH was between 8·40 and 8·50. Salinity was higher than in the Thollayiram Par region and the salinity was between 32·04 °/oo and 32·28°/oo. The water was 90 per cent saturated with oxygen. Calcium concentration was very low and the calcium-chlorine ratio was between 0·01971 and 0·02020 which is rather low then compared with normal values of Thomson and Wright (1930), Kirk and Moberg (1933), Nisikawas (1939), Sverdrup *et al* a Mitada (1951) and Chow and Thomson (1955). The water was rich in silicate, but poverty conditions of phosphate, nitrate and iron were observed. The conditions existing in the bank do not appear to be favourable for the Indian pearl oyster.

Parkandanyan Par (Station X-*a*, dated 20th January 1959 in Table II).—This bank lies south, west of Thollayiram Par and Koothadiar Par at 14·5 metres limit. The bottom was rocky with sand. The water was bluish with a visibility of 11·5 metres. The bottom water was moderately warm with 26·6°C and 26·3°C at the surface on 20th January 1959, pH was between 8·50 and 8·45, high salinity of 33·39 °/oo both at the surface and bottom, and the super saturation with oxygen and high concentration of calcium with calcium-chlorine ratio of 0·02245 were the other features of the water. The water was fairly rich in other nutrients like silicate, phosphate, nitrate and iron. The conditions of the bank appear to be favourable for the Indian pearl oysters.

Nenjurichan Par (X-*b*, dated 20th January 1959 in Table II).—This bank lies south and south-east of Parkandanyan par at 15·0 metres limit. Bottom was rocky with sand spread over. Water was bluish with a transparency of 11·5 metres. Current was from north to south Sea was rough with waves. The water was warm at the bottom having a temperature of 26·7°C. The surface temperature was 26·40°C and pH was between 8·45 and 8·50. Salinity was 33·39°/oo and the water was super saturated with oxygen. Calcium concentration was high and the calcium-chlorine ratio was 0·02245. Richness in silicate and much paucity in phosphate, nitrate and iron were the other features of the water. But for the poverty conditions of the nutrients, the bank may be taken as a good pearl bank.

Vada Oli Pathu Par (X–*c*, dated 20th January 1959 in Table II).—This lies at 18·0 metres with rocky bottom spread over with sand and nullipores. The water was blue with 11·5 metres of transparency. Current was from north to south. Sea was rough with waves. Bottom water was fairly warm (26·8°C) while the surface temperature was only 26·5°C, pH was between 8·45 and 8·50.

Salinity was 33·39°/oo, water was super-saturated with oxygen with a high calcium content and the calcium chlorine ratio between 0·02245 and 0·02262. Fairly rich silicate and iron content and poor phosphate and poverty and even absence of nitrate were the other features of the water. But for the poverty of nutrients, the bank may be considered as a good Pearl Bank.

Melaompathu Par (V–c, dated 23rd December 1958 in Table I).—This bank lies adjacent to Nenjurichan Par on the east a little towards south at 16 metres limit. Bottom was rocky covered with sand. The water was blue with 10·0 metres of transparency. The temperature of water was between 26·8°C and 27·1°C at surface and 26·5°C and 27·2°C at the bottom, pH was between 8·45 and 8·50. Salinity was between 32·35°/oo and 32·02°/oo at the surface and 31·94°/oo and 32·00°/oo at the bottom. The oxygen concentration is slightly less and water was 50·80°/oo saturated with oxygen. Calcium concentration was rather low and the calcium chlorine ratio was between 0·02014 and 0·02017. The water was very rich in silicate (11·76)/ mgm./L at surface. Either conditions of poverty or absence in respect of other nutrients like phosphate, nitrate and iron were observed.

Melaompathu outside.—Region is sandy with temperature of 26·7°C at surface and 27·0°C at bottom, pH between 8·45 and 8·50 and low salinity of 31·98°/oo at the surface and 31·94°/oo at the bottom. The water was about 90 per cent saturated with oxygen at the surface and 82 per cent at the bottom. Calcium chlorine ratio was very low between 0·01973 at surface and 0·02027 at the bottom. Water was rich in silicate and iron and fair in the case of phosphate and nitrate. Low salinity and oxygen and poor concentration of nutrients and calcium existing in the bank do not appear to be very favourable for pearl oysters.

Vadaompathu Par (VI-*a*, *b*, dated 27th December 1958 in Table I).— Lies due west and a little towards south of Parkondanyan par at 13–15 metres limit with rocky bottom with or without sand. Water was blue in colour with a transparency of 10·0 metres and fairly warm with temperature between 26·5°C and 26·7°C at the surface and 26·4°C and 26·8°C at the bottom, pH 8·50, salinity was low with 31·98°/oo at the surface and 31·89°/oo at the bottom. Water was super-saturated with oxygen at the surface but the bottom water was only 80–90 per cent saturated. Calcium chlorine ratio was between 0·01875 and 0·1945. Though rich in silicate, the water suffered poverty of phosphate and absence of nitrate. The conditions existing in the par do not appear to be favourable for the Indian pearl oyster.

Saithmpathou par (VI-c, dated 27th December 1958 and VII-c, dated 29th December 1958. in Table I).—This par lies adjacent to Vadaombathu on SE at 13–15 metres limit, with rocky bottom throughout. The water was attractive blue with transparency of 10·0 metres in the northern region and 11·0 metres in the southern region. The water is fairly warm at the bottom with temperature between 26·7°C and 27·0°C at the bottom and 26·8°C and 26·50°C at the surface, pH was between 8·50 and 8·55. Salinity was low but the northern region exhibited higher salinity 31·89 per cent to 31·98 per cent. At the southern region it was between 31·61°/oo and 31·67°/oo. Water was super saturated with oxygen in the south and almost saturated in the north calcium concentration was very poor and the calcium chlorine ratio was very low between 0·01875 and 0·01969. Northern region was fairly rich in silicate, phosphate, nitrate and iron while the southern region exhibited poverty conditions and even absence in respect of phosphate, nitrate and iron. Silicate was fairly rich. The conditions existed in the par do not appear to be favourable for the pearl oyster.

Puli Pundu Par (VII-*a*, *b*, dated 29th December 1959 in Table I).—This is located down south of Vadaompathu and south-west of Saithompathu par at 15 metres limit. Bottom was rocky with a little sand spread over in certain places. Water was bluish with a visibility of 11·0 metres. Current was from north to south and the sea rough with waves. The temperature was between 26·2°C and 26·5°C at the surface and 26·6°C and 26·4°C at the bottom, pH was between 8·5 and 8·55. Low salinity between31·58°/oo and31·63°/oo saturation with oxygen both at the surface and bottom and very poor concentration of calcium with Ca/Cl ratio between 0·01963 and 0·1970 were the chief factors. The water was also fairly rich in *silicate and iron while nitrate and phosphate were poor.* The conditions cannot be considered as suitable for the Indian pearl oysters.

Pinnakayal Sultan Par (VIII-*a*,dated 10th February 1959 in Table III).—Lies south-west of Pulipundu par and due east of Pinnakayal at 15 metres limit. Bottom was rocky covered with sand admixed with broken shells.

The water was greenish blue with a transparency of 10·0 metres. Current was from N-S. Calm conditions prevailed at sea.

The water was warm with temperature between 27·5°C at the surface and 27·7°C at the bottom, pH was between 8·35 and 8·40. High salinity between33·81°/oo and 33·77°/oo with super-saturation of oxygen with a low Ca/Cl ratio between 0·02020 and 0·02085 and fairly rich silicate and iron were the features of the water. Phosphate and nitrate were poor. Conditions on this bank do not appear to be very favourable for Indian pearl oyster.

Sankuraya Pathu Par (XVIII-*b*, dated 10th February 1959 in Table III).—Lies south-east of Pinnakayal Sultan par at 17·0 meters limit. Bottom is rocky covered with sand admixed with broken shells. Water was greenish with a transparency of 10·0 metres. Current was N-S. Sea was calm. Temperature was 27·4°C at the surface and 27·8°C at the bottom and pH between 8·40 and 8·35°/oo High salinity between 33·77°/oo at the surface and 33·83°/oo at the bottom with supersaturation of oxygen and high concentration of calcium (Ca/Cl ratio being from 0·02329 and 0·2375) fairly rich silicate and very poor phosphate, nitrate and iron were the features of the water. But for the poverty of nutrients and the sand covering of the bed, the bank may be taken as a good pearl bank.

Rajavakku Sippi Sothitcha par (IX-*a*, *b*. dated 17th January 1959 in Table II).—Lies down south of Pinnakayal sultan par and due west of Sankuraya Pathu at 14·0150 meters limit. Bottom was rocky throughout.

Water was bluish with a transparency of 12·5 metres. Current was from north to south and the sea was rough with waves. The temperature was between 26·7°C and 26·9°C at surface and 26·8°C and 27·0°C at the bottom on 17th January 1959. pH ranged between 8·45 and 8·50. Salinity was high and was 33·12°/oo throughout. Water was super saturated with oxygen at the surface in the northern region and almost saturated in the southern region. The concentration of oxygen at the bottom was slightly less. The calcium concentration was invariably high and the Ca/Cl ratio was above 0·0220. The very high Ca/Cl ratio of 0·02418 at the surface of the northern region is rather strange. The water was very rich in silicate and fairly rich in iron. Poverty of phosphate and nitrate were observed throughout. But for the poverty of nitrate and iron the conditions in the bed can be taken as quite suitable for the Indian pearl oyster.

Kudamuthu Par (VIII-*a*, *b* and *c*, dated 12th January 1959 in Table II).—Adjacent to the Rajavukku Sippi Sotichappar, it lies on the south a little towards west at 14 metres limit. The bottom was rocky throughout with sand spread over it. The sandy layer was thick in western region. The water was blue with 12·0 metres of transparency. Current was from N-S and the sea was rough with waves. The temperature was between 26·3°C and 26·6°C on 12th June 1959 bottom water being warmer, with pH between 8·45 and 8·50. Salinity was between 32·62°/oo and 32·75°/oo with super saturation of oxygen. The calcium concentration was high. The sudden drop in the calcium at the surface in the central region is sugestive of greater utilisation of calcium. The Ca/Cl ratio was between 0·02060 and 0·02382. The water was fairly rich in silicate and iron. Phosphate and nitrate were poor. But for the poverty of phosphate and nitrate the par may be termed as a very good pearl bank.

Saithu Kudamuthu par (IX-*c*, dated 17th January 1959).—Adjacent to the Kudamuthu par it lies on the south at 14 metres limit. The bottom was rocky. Water was blue with a transparency of 12·5 metres. Current was N-S and the sea rough with waves. The temperature was 26·9°C pH between 8·40 and 8·50 and salinity 33·12°/oo. The water was about 85 per cent saturated with oxygen. Calcium concentration was very high and the Ca/Cl ratio was between 0·02302 and 0·02344. The water was rich in silicate and fairly rich in iron, phosphate and nitrate. The conditions in the bed are suggestive that the par is a productive pearl bank.

Kadayan par (XVI-*a*, dated 6th February 1959.—Table III).—Lying south-east of Saithu Kudamuthu Par it is due east of Kayalpatnam, an important village between Tiruchendur and Pinnakoil, and at 14·5 metres limit. The bed was rocky with a little sand over it. The water was bluish with a transparency of 11·0 meters. Current was north to south and sea was rough with waves. The water was warm with temperature of 28·4°C at surface and 28·2°C at bottom, pH between 8·45 and 8·50, high salinity between33·89°/oo and 33·91°/oo with a high concentration of calcium with Ca/Cl ratio between 0·02281 and 0·02328 and about 70 per cent saturation of oxygen at the surface and 85 per cent at the bottom are the features of the water. Very rich silicate and fairly rich iron and poor phosphate and nitrate are the features of the nutrient contents of the water. Conditions in the bank are quite favourable for the Indian pearl oysters. But for the poverty of phosphates and nitrates, the bank can be compared with Devi par.

Kanawa par (XVI-*d*, dated 6th February 1959, in Table III).—Lies south and a little towards east of Kadayan par at 14·5 metres limit. The rocky bottom is covered with sand. Water was light bluish with a visibility of 11·0 metres current was north to south and sea was rough with waves. Temperature was 28·3°C at the surface and 28·2°C at the bottom, pH was between 8·45 and 8·50, high salinity between 33·88°/oo and 33·90°/oo 75·85 per cent saturation of oxygen, high concentration of calcium, very rich silicate and fairly rich iron and very poor phosphate and nitrate were the features of the water. Ca/Cl ratio was between 0·02260 and 0·02347. The condition of the bank is quite comparable with that of Kadayan par.

Nadumalai Piditha par (XVI-*c*. dated 6th February 1959 in Table III).—Lies down south of Kanawa par at 15·5 meters limit The rocky bottom is covered with sand and nullipores. Water was light blue with a transparency of 11·0 metres. Current was north to South. Sea was rough with waves. The temperature was 28·5°C at the surface and 28·3°C at the bottom, pH was between 8·40 and 8·45. Salinity was high being 33·90°/oo at the surface and 33·93°/oo at the bottom. Oxygen was very low at the surface being only about 45 per cent saturation but high at bottom with a saturation of about 80 per cent. High calcium with Ca/Cl ratio between 0·02302 and 0·02371 and very rich silicate and rich iron and poor phosphate and nitrate were the features of the nutrient content of the water. The poor oxygen at the surface and rich silicate are suggestive of slow photo synthesis and dissolution of silicate from the exo-skeletons of diatoms. But for the poverty of nitrate and phosphate, the bank may be said to be a very good pearl bank.

Karai Karuval par (XI-*a*, dated 21st January 1959 and XIV-*a* and *b*, dated 30th January 1959 in Table II).—This is a productive par in the southern half of the division lying south of Kadayanpar and a little towards north of Tiruchendur at 15 metres limit. Flat rocky bottom with a little sand spread over in the northern region and sand, sea weeds and sponges in the central region. The water was of bluish hue with 12·0 to 14·0 metres of visibility. Current was from north to south. The bottom water was fairly warm and the temperature was between 26·5°C and 27·7°C and at the bottom 26·8 and 27·5°C, pH was between 8·40 and 8·45, high salinity between 33·39 and 34·95°/oo and up to 100 per cent saturation with oxygen and with abnormally high calcium concentration haying the Ca/Cl ratio between 0·0248 and 0·02325 on 21st January 1959 and between 0·02172 and 0·02203 on 31st January 1959 and rich nutrients like silicate phosphate and nitrate and iron were the features of the water. Iron was uniformally high.

Vilangu Karuval par.—Lies south of Karai karuval par slightly towards the east at 15·0—18·0 metres limit. Southern and northern regions are deeper. The rocky

bottom was a little sandy at the NW and NWN. Water was bluish with 12·0–14·0 meters of visibility. Southerly current and calm conditions prevailed. The bottom water was invariably warmer with a temperature difference up to 1·20°C. The temperature was between 33·39 per cent and 33·43 per cent and either 100 per cent saturation or super-saturation with oxygen, high calcium generally were the features of the water of the bank. Iron in the par was uniformly high. Low phosphate and nitrate were observed at station N2 and N 4. Similarly the oxygen was only 80·85 per cent saturation at NWN. The conditions existing in the par are very suitable for the Indian Pearl Oyster.

Tiruchendur poonthottam par (XVII-*a*, dated 7th February 1959 in Table III).—Lies down south little towards east of Vilangu Karuval par at 15·0 meters limit. The bottom was flat. rocky with little sand. Water was bluish with 9·0 meters of transparency. Current was north to south and sea rough with waves. Water was warm with 28·2°C at surface and 28°C at bottom, pH was between 8·35 and 8·45, high salinity between 33·87°/0 and 33·91°/0. 90–95 per cent saturation with oxygen, high calcium, silicate, fairly rich iron and poor phosphate and nitrate were the features of the water. The calcium chlorine ratio was between 0·02303 and 0·02347. The conditions of the bank appear to be quite favourable for the Indian Pearl Oyster.

Off Manapad (*a* and *b*., dated 6th May 1959 in Table VI).—Lies 13 miles east of Manapad point 8°—22′50″ N and 78° 19E at 19-5–20-0 meters limit. The rocky bottom with sand throughout was rich in sponges and live-corals in certain areas. Water was blue with 12·0 meters of transparency. Current was south to north. Sea was rough with high waves. Water was very warm between 30·2°C. and 30·4°C, pH between 8·40 and 8·55, high salinity between 34·50°/00 and 30·57°/00 with a high saline surface and 80·0 per cent saturation with oxygen, very high calcium, rich silicate and fairly rich iron, phospate, and nitrate were the features of the water. The Calcium-chlorine ratio was between 0·02306 and 0·02342. The conditions of the bank appear to be favourable for the Indian Pearl Oyster.

Discussions

The pearl banks of this division lie within 15·0—20·0 meters limit though certain portions of the pars were deeper. Bottom was rocky (calcite) with or without sand and sometimes admixed with shell grit. The sandy layer in certain areas were so thick as to give the impression of a sandy stratum. Nullipores, sea-weeds, sponges and madrepores were met with in Thollayiram par, Karuval par and the par off Manapad.

The water was warm and temperature up to 31·1°C has been recorded. The variation in temperature of the water was almost in consonance with the temperature of the air over lying. But due to the full sway of north-east monsoon the surface temperature of water was low, and occasionally cooler surface waters and warmer bottom waters were observed. Salinity was low in December-January and thereafter it was in the ascending trend. The low salinity during the period might probably be due to the north south current carrying cooler and less saline water from the Palk Bay. Cooler and high saline surface water and warmer and less saline bottom water observed in Kothadiar par, Vadapompathu par and in Thollaiyiram par have also been recorded by Pearson (1922) Sewell (1925) and Chacko *et al* (1954).

The water was generally saturated with oxygen. Even super-saturated water with oxygen was common. The water was generally rich in calcium and the Ca/Cl ratio was above 0·022. Silicate was also uniformly rich throughout although sudden fluctuations have been observed. Silicate contents up to 14·3 gm. at / L of silicate-silicon have been observed. Phosphate and nitrate were undergoing sudden fluctuations, even poverty and conditions of starvation have also been recorded in respect of these nutrients. Although values as high as 23·2 gm. at /L phosphate-phosphorus and 4·25 gm. at /L of nitrate-nitrogen have also been observed. Iron also was undergoing sudden variation, conditions of absence as well as plenty up to 10·2 kgm. at /L having been observed. The pearl fishery of 1958–59 was a success. A total of 16,500,000 oysters with good pearl-content were fished, yielding a revenue of Rs. 8,00,000, to the Government. The main banks exploited were Tiruchendur Poonthotam par, Karuval par, Saithukudamuthu par and Kadamuthu par. A careful comparison of the conditions existing in these banks will throw light on the ideal conditions of the Indian Pearl Oyster. Rocky bottom with a little admixture of sand and shell grit spread over and warm and high saline water, fairly saturated with oxygen having a high concentration of calcium, with Ca/Cl ratio invariably above 0·0220, and fairly rich nutrients like silicate, phosphate, nitrate and Iron may be said to be quite suitable for the Indian pearl oyster. It may now be said that the conditions existing in Devi par, Fernando par, Nagarai par, Athampòthu par and Thollayiram par, Parkandajan par, Rajavukku chippi Sothitcha par, Kudamathu par, Saithu Kodamuthu par and Thiruchendur Poonthottam par are quite suitable for the Indian Pearl Oyster.

Summary.

1. The physico-chemical conditions existing in the Indian Pearl Banks of the Central division of the Gulf of Mannar from December 1958 to May 1959 were examined and discussed.

2. The warmer and high saline water with fair percentage of oxygen and high calcium chlorine ratio of the pearl banks was discussed.

3. The ideal conditions for the Indian Pearl Oysters have been brought out.

4. The promising pearl banks have been indicated.

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TABLE 1—*Showing physico-chemical conditions of Pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres)*	*Nature of bottom.*	*Visibility. (metres).*	*Current.*	*Sea or swell.*
10th December 1958 *Thollayiram par (Central)*—							
I *a*	Bottom	Fine bluish Green.	19·0	Rocky with sand	10·5	N—S	Sea high ways
b	Do	Do.	19·0	Do.	11 0	N—S	Do.
16th December 1958 *Karai par (Utti par)*—							
II *a*	Surface	Bluish green.	13 0	Flat rocky with sand.	10·0	N—S	Sea highways
	Bottom	..	..	..	..	..	..
19th December 1958 *Thollayiram par (Northern region)*—							
III *a*	Surface	Fine Blue	17 8	Rocky with sand and Nellipore.	11·0	N—S	Sea highways
	Bottom						
b	Surface	Do	19 8	Sandy	11·0	N—S	Do.
	Bottom						
c	Surface	Do	15 0	Rocky with sand and Nellipore.	11·0	N—S	Do
	Bottom						
d	Surface	Do.	18 0	Do.	11·5	N—S	Do.
	Bottom						
e	Surface	Do.	17·5	Do.	11 5	N—S	Do.
	Bottom						
23rd December 1958 *Kuthadiar Par*—							
V *a*	Surface	Blue	17 0	Rocky	10 0	N—S	Sea waves
	Bottom	..		....	..		
b	Surface	Do.	16·0	Sandy	10·0	N—S	Do.
	Bottom	..	..	....	..	..	....
Melaombathu Par—							
c	Surface	Blue	16·0	Rocky	10 0	N—S	Sea waves
	Bottom	.	..	..	..	..	...
d	Surface	Do.	16·0	Sandy	10·0	N—S	Do.
	Bottom	..	..	..	..	..	....
Outside Melaombathu par—							
e	Surface	Blue	18·0	Sandy	10·0	N—S	Sea waves
	Bottom	..	..	..	..	..	....
27th December 1958 *Vadaombathu par*—							
VI *a*	Surface	Blue	13·0	Rocky	10·0	N—S	Sea waves
	Bottom	..	..	..			
b	Surface	Do.	15 0	Rocky with sand	10·0	N—S	Do
	Bottom	..		..	..	..	....
Sadhombathu Par (North)—							
c	Surface	Attractive blue.	13 0	Rocky	10·0	N—S	Do.
	Bottom			....	..	—	....
29th December 1958 *Pulipoondu par* —							
VII *a*	Surface	Blue	15 0	Rocky with sand	11·0	N—S	Sea high waves
	Bottom			....	..		....
b	Surface	Do.	15 0	Rocky	11 0	N—S	Do.
	Bottom			....	..	..	
Sathombathu par (South)—							
c	Surface	Blue	15·0	Rocky	11·0	N—S	Do.
	Bottom						

Banks off Tuticorin during December 1958.

Temp. °C.	*Sp. gr.*	*pH.*	*S°/oo.*	*Dissolved O_2 ml/L.*	*Excess base mg/L.*	*Calcium Mgm./L*	*Silicate Mgm./L*	*PO_4—P Mgm./L*	*NO_3—N Mgm./L*	*Iron Mgm./L*	*Remarks.*
26·9	21·3	8·35	32·28	5·25	75·00	9,658	0·87	0·80	1·20	0·30	..
26·8	21·3	8·50	32·30	5·15	81·00	9,863	1·12	0·42	0·80	..	..
27·4	21·3	8·50	32·14	5·14	66·00	10,160	1·00	0·95	1·00	0·25	..
27·0	21·4	8·45	32·23	5·07	69·00	10,040	1·35	0·95	0·80	0·40	..
27·5	21·0	8·40	31·33	4·38	79·50	9,190	0·71	0·08	0·10	0·10	..
27·3	21·1	8·45	31·74	5·07	76·50	9,350	0·90	0·20	0·45	0·40	..
27·5	21·0	8·40	31·38	4·25	75·00	9,270	1·12	0·38	0·75	..	.. Outside the par.
27·46	21·1	8·40	31·70	4·32	81·00	9,350	0·90	1·65	2·85	0·35	
27·6	21·0	8·45	31·38	4·40	75·00	9,150	1·34	0·80	0·90	0·50	
27·4	21·2	8·45	31·74	4·48	76·20	10,000	5·70	0·40	0·40	0·32	..
27·6	21·0	8·45	31·38	4·40	76·80	9,150	1·03	0·30	0·40	0·10	..
27·5	21·1	8·45	31·70	4·25	79·80	9,350	1·34	0·30	0·40	1·60	..
27·7	21·0	8·40	31·30	4·30	75·00	9,190	1·04	0·20	..	0·35	..
27·5	21·1	8·40	31·65	4·52	79·80	9,400	1·45	0·10	0·08	1·80	..
26·75	21·3	8·45	32·28	4·25	78·00	9,030	1·25	0·10	0·10	0·35	..
27·20	21·2	8·40	32·23	4·03	81·00	8,950	2·14	0·28	0·30	0·40	..
26·55	21·0	8·50	32·04	3·84	81·00	8,740	1·60	0·15	..	0·20	..
27·2	21·2	8·50	32·15	4·11	79·80	9,190	7·48	0·25	0·30	0·40	..
26·80	21·3	8·45	32·33	3·97	81·00	9,030	11·76	0·08	..	..	..
26·50	21·0	8·90	31·94	3·81	81·00	8,950	1·60	0·25	0·30	0·50	..
27·1	21·2	8·45	32·12	2·47	79·50	8,950	0·60	0·10	..	0·20	..
27·2	21·2	8·50	32·00	3·25	79·50	8,950	1·80	0·36	0·40	0·50	..
26·7	21·2	8·45	31·98	4·45	79·80	8,740	1·32	0·30	0·40	1·00	..
27·0	21·2	8·50	31·94	4·00	81·00	8,950	1·35	0·72	1·00	1·80	..
26·50	21·3	8·50	31·98	5·00	80·10	8,540	0·78	0·08	..	..	..
26·4	21·3	8·50	31·89	4·18	78·00	8,340	4·70	0·10	..	0·15	..
26·70	21·3	8·50	31·98	5·07	78·60	8,540	1·11	0·20	0·30	0·28	..
26·80	21·3	8·45	31·89	4·32	77·10	8,580	1·17	0·35	0·50	1·50	..
26·8	21·3	8·50	31·98	4·52	80·00	8,540	0·71	0·75	0·80	2·50	..
26·7	21·3	8·50	31·89	4·38	78·00	8,580	1·50	0·85	0·85	2·50	..
26·2	21·4	8·55	31·63	4·73	84·00	8,620	1·01	0·20	0·20	1·00	..
26·6	21·3	8·50	31·63	5·20	84·00	8,580	8·91	0·35	0·40	1·50	..
26·5	21·3	8·50	31·58	5·00	82·80	8,580	1·19	0·15	0·10	0·80	..
26·4	21·3	8·50	31·58	4·66	82·80	8,580	2·99	0·45	0·50	0·95	..
26·5	21·3	8·55	31·61	5·27	81·60	8,400	0·82	0·30	0·10	0·10	..
27·0	21·2	8·50	31·67	5·00	82·60	8,640	1·07	0·20	..	..	..

TABLE 2—*Showing physico-chemical conditions of Pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibility. (metres).*	*Current.*	*Sea or swell.*
12th January 1959 *Kudumuthu Par (North)*—							
VIII *a*	Surface	Blue	14·0	Sandy	12·0	N—S	Sea high waves
	Bottom						
b	Surface	Blue	14·0	Rocky with sand	12·0	N—S	Sea high waves
	Bottom						
c	Surface	Blue	14·0	Rocky [white	12·0	N—S	Sea high waves
	Bottom						
17th January 1959 *Rajavucku Chippi Sothitcha Par*—							
IX *a*	Surface	Blue	15·0	Rocky	12·5	N—S	Sea waves
	Bottom						
b	Surface	Blue	14·0	Rocky	12·5	N—S	Sea waves
	Bottom						
Saith Kudamuthu Bar—							
c	Surface	Blue	14·0	Rocky	12·5	N—S	Sea waves
	Bottom						
20th January 1959 *Parkudainthan Par*—							
X *a*	Surface	Blue	14·5	Rocky with sand	11·5	N—S	Sea small waves.
	Bottom						
Nenjurithan Par—							
b	Surface	Blue	15·0	Rocky and sand	11·5	N—S	Sea small waves
	Bottom						
Vadaolippathu Par—							
c	Surface	Blue	18·0	Rocky with Nullipore and sand.	11·5	N—S	Sea small waves.
	Bottom						
21st January 1959 *Karai Karuval Par*—							
XI *a*	Surface	Blue	15·0	Rocky	14·0	N—S	Swell
	Bottom						
Vilangu Karuval Par—							
b	Surface	Blue	15·0	Rocky	14·0	N—S	Swell
	Bottom						
27th January 1959 *Athuompathu Par*—							
XII *a*	Surface	Greenish Blue	15·0	Sand with broken shells.	14·0	N—S	Waves
	Bottom						
Patharai Par—							
b c	Surface	Greenish Blue.	15·0	Sand over Flat rock ..	14·0	N—S	Waves
	Bottom						
Pasi Par—							
d	Surface	Greenish Blue	16·0	Sandy	14·5	N—S	Waves
	Bottom						
28th January 1959 *Cruxian Par*—							
XIII *a*	Surface	Green	12·0	Small broken shells and sand over rocks.	10·0	N—S	Waves
	Bottom						
Vantheevu Arupagum Par—							
b	Surface	Green	12·0	Sandy	10·0	N—S	Waves
	Bottom						
Nagarai Par—							
d	Surface	Green	12·5	Rocky with little sand.	10·0	N—S	Waves
	Bottom						
30th January 1959 *Vilangu Karuval Par (North Karuval)*—							
XIV *a*	Surface	Blue	15·0	Flat rocky with sand weeds and sponges.	12·0	N—S	Swell
	Bottom						
c	Surface	Blue	15·0	Flat Rocky with sand.	12·0	N—S	Swell
	Bottom						
31st January 1959 *Vaipar*—							
XV *a*	Surface	Green	13·5	Sandy with mud layer.	10·0	N—S	Ripple
	Bottom						
b	Surface	Green	14·0	Sandy with mud and Nullipore and Madripore and rocky below ½ to ½ meter.	10·0	N—S	Ripple
	Bottom						
Devi Par—							
c	Surface	Green	11·0	Rocky	10·0	N—S	Ripple
	Bottom						

Banks off Tuticorin during January 1959.

Temp. °C.	*Sp gr.*	*pH.*	*S°/oo.*	*Dissolved O_2 ml/L.*	*Excess base m/L.*	*Calcium Mgm. /L.*	*Silicate Mgm. /L.*	*PO_4—P Mgm. /L.*	*NO_3—N Mgm. /L.*	*Iron Mgm /L.*	*Remarks.*
26·3	21·9	8·45	32·62	5·45	70·18	10,370	0·98	0·20	0·21	0·35	West.
26·5	21·9	8·45	32·67	4·90	70·18	10,370	0·98	0·32	0·25	0·40	..
26·6	21·9	8·50	32·67	5·11	70·69	9,354	1.07	0·18	..	0·25	Central.
26·6	21·9	8·50	32·75	5·18	69·39	10,580	1·21	0·30	0·20	0·70	..
26·6	21·9	8·45	32·67	5·18	71·47	10,580	0·98	0·10	..	0·40	East.
26·6	21·9	8·50	32·67	5·18	71·47	10,770	1·25	0·10	..	0·25	..
26·7	22·0	8·45	33·21	5·04	72·78	10,870	1·65	0·30	0·22	0·70	North
26·8	22·0	8·45	33·21	4·49	71·49	10,370	3·21	0·35	0·20	0·60	..
26·9	22·0	8·50	33·21	4·56	70·18	10,450	1·80	0·20	0·18	0·85	South.
27·0	22·0	8·50	33·21	4·43	70·18	10,370	3·56	0·35	0·45	0·90	..
26·9	22·0	8·40	33·21	4·04	71·47	10,770	1·60	0·25	0·30	0·50	West.
26·9	22·0	8·50	33·21	3·97	72·78	10,580	1·78	0·40	0·28	0·75	..
26·3	22·2	7·50	33·39	4·90	70·18	10,370	1·16	0·45	0·50	1·00	Central.
26·6	22·1	8·45	33·39	4·63	68·87	10,250	0·89	0·45	0·60	0·92	..
26·4	22·1	8·45	33·39	4·97	70·18	10,370	1·34	0·25	0·20	0·35	Central.
26·7	22·0	8·50	33·29	4·97	70·18	10,330	1·17	0·40	0·30	0·50	Central.
26·5	22·1	8·45	33·29	4·83	70·18	10,450	0·98	0·10	..	0·80	Central.
26·8	22·0	8·50	33·39	5·00	68·87	10,370	1·07	0·18	..	0 20	..
26·5	22·1	8·40	33·39	4·90	72·00	10,740	0·71	0·90	0·95	2·00	Central.
26·8	22·0	8·45	33·39	5·45	72·00	11,190	0·62	0·82	1·00	3·50	..
26·5	22·1	8·40	33·39	4·80	71·40	10,700	1·03	0·75	0·95	2·14	Central.
26·8	22·0	8·40	33·39	4·90	70·50	10,700	0·96	0·82	1·10	4·02	..
27·0	21·7	8·40	33·11	5·42	71·00	10,410	1·00	0·85	0·88	1·00	South.
27·1	22·0	8·40	33·84	4·70	70·50	10,370	1·10	0·96	1·00	1·50	..
27·2	22·0	8·50	32·90	4.12	70·50	10,250	0·96	0·72	0·80	0·10	Central.
27·2	21·9	8·45	33·66	4·52	70·50	10,370	0·85	0·90	0·80	1·10	..
27·1	21·5	8·50	32·94	4·25	70·50	10,000	1·10	1·00	1·10	2·50	West.
27·4	22·0	8·40	33·84	4·35	69·60	10,250	1·50	1·25	1·30	4·00	..
26·9	21·6	8·50	33·01	4·15	70·50	10,000	0·95	0·95	1·00	1·85	Central.
27·0	21·8	8·50	33·04	4·15	69·90	10,250	1·25	0·95	1·00	3·50	..
27·0	21·6	8·50	33·05	4·00	70·50	10,100	1·00	1·17	0·70	1·50	East.
26·9	21·8	8·45	33·00	4·04	70·50	10,300	1·45	2·00	1·70	1·75	..
27·4	21·6	8·55	33·05	3·75	70·50	10,200	1·50	1·25	1·30	2·00	Central.
27·2	21·8	8·45	33·42	4·00	69·60	10,320	2·10	1·75	2·15	4·50	..
27·5	22·0	8·40	33·85	4·00	70·50	10,220	1·85	0·90	1·00	1·85	Central.
27·5	22·0	8·45	33·92	3·45	69·00	10,300	2·50	0·85	0·50	3·70	..
27·7	22·0	8·40	33·88	4·14	69·60	10,300	2·00	0·85	1·05	1·55	North.
27·5	22·0	8·45	34·95	4·14	69·60	10,350	2·50	0·90	0·75	3·50	..
27·7	22·0	8·45	33·85	4·07	67·80	10,300	1·32	1·00	0·85	1·25	Central.
28·9	21·6	8·40	33·94	4·62	67·80	10,400	1·58	1·15	1·10	3·25	..
27·9	22·0	8·45	33·90	4·21	67·50	10,300	1·25	1·05	1·00	1·50	East.
27·6	22·0	8·40	33·94	4·21	67·80	10,400	1·50	1·25	1·35	3·50	..
28·3	21·6	8·45	33,78	4·15	67·50	10,250	1·50	1·10	1·00	2·50	Central.
27·6	22·0	8·40	33·85	4·39	69·00	10,300	2·50	1·25	1·50	4·00	

TABLE 3.—*Showing physico-chemical condi ions of Pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature or bottom.*	*Visibility. (metres).*	*Current.*	*Sea or swell.*
6th February 1959 *Kadayan Par—*							
XVI *a*	Surface	Blue	14·5	Rocky with slight sand (3 cm.)	11·0	N—S	Sea high waves.
	Bottom	..					
Kanava Par—							
b	Surface	Slight	14·5	Sandy ..	11·0	N—S	Do.
	Bottom	Bule	..			..	..
Nadumalai Peditha Par—							
c	Surface	Slight	15·5	Sand over rock	11·0	N—S	Sea high waves.
	Bottom	Blue	..	..	..	..	..
7th February 1959 *Thiruchendur Poonthondam Par—*							
XVII *a*	Surface	Blue	15·0	Flat rock with sand ..	9·0	N—S	Sea high waves.
	Bottom	..	..	..	..	..	..
10th February 1959 *Pinnakayal Sulthan Par—*							
XVIII *a*	Surface	Greenish	15·0	Sandy with broken shell.	10·0	N—S	Swell
	Bottom	Blue	..	..	..	..	..
Sanguraya Pathu Par—							
b	Surface	Greenish	17·0	Do.	10·0	N—S	Swell
	Bottom	Blue	..	..	..	..	..
16th February 1959 *Devi Par—*							
Central	Surface	Attractive blue	11·55	Flat rock with 2 cm. of sand.	10·0	N—S	Swell
	Bottom	..	..	..	..	..	..
N2	Surface	Attractive blue	12·0	Flat rock and sand ..	10·0	N—S	Swell
	Bottom		..	..	..	..	..
n4	Surface	Attractive blue	11·5	Flat rock with 5 cm. of sand.	10·0	N—S	Swell
	Bottom	..	..	..	..	..	..
18th February 1959 *Devi Par—*							
W1	Surface	Attractive blue	11·0	Rock with 2 cm. of sand.	8·0	N—S	Swell
	Bottom	..		..	..	..	..
W2	Surface	Attractive blue	12·0	Do.	8·0	N—S	Swell
	Bottom	..	..	..	..	..	..
W3	Surface	Attractive blue	12·0	Rock with 8 cm. of sand.	8·0	N—S	Swell
	Bottom	..	..	..	..	..	..
20th February 1959 *Devi Par—*							
SE1	Surface	Attractive blue	11·0	Rock with little sand.	7·5	N—S	Ripples
	Bottom	..	..	..	..	..	..
SE2	Surface	Attractive blue	13·0	Sandy (10 to 12 cm.). Sand.	7·5	N—S	Ripples
	Bottom	..	..		..	..	..
SE3	Surface	Attractive blue	13·0	Sandy ..	7·5	N—S	Ripples
	Bottom	..	..	..	..	..	..
23rd February 1959 *Devi Par—*							
	Surface	Attractive blue	11·5	Flat rock with little sand.	8·0	N—S	Ripples
	Bottom	..	..		..	..	..
	Surface	Attractive blue	11·0	Do.	8·0	N—S	Ripples
	Bottom	..	..	..	..	..	
	Surface	Attractive blue	11·5	Do.	8·0	N—S	Ripples
	Bottom		..	..	..	..	
25th February 1959 *Fernando Par—*							
W2	Surface	Blue	10·5	Flat rock	8·0	N—S	Ripples
	Bottom	..	..	..	..	..	..
E2	Surface	Blue	11·5	Flat rock ..	8·0	N—S	Ripples
	Bottom	..	..		..	..	..
S2	Surface	Blue	11·0	Flat rock with little sand.	8·0	N—S	Ripples
	Bottom	..	..	..	..	..	..

Banks off Tuticorin during February 1959.

Temp °*C*	*Sp. gr.*	*pH.*	*S°/oo.*	*Dissolved* O_2 *ml/L.*	*Excess base mg./L.*	*Calcium Mgm. /L.*	*Silicate Mgm. /L.*	PO_4—*P Mgm. /L.*	NO_3—*N Mgm. /L.*	*Iron Mgm. /L*	*Remarks.*
28·4	21·5	8·50	33·89	3·10	83·54	10,700	2·45	0·10	..	0·90	
28·2	21·5	8·45	33·91	3·86	89·28	10,920	2·14	0·25	0·30	0·85	
28·3	21·5	8·50	33·88	3·59	89·28	10,600	2·76	0·10	..	0·90	
28·2	21·5	8·45	33·90	4·00	89·28	11,000	0·85	0·15	0·25	0·90	
28·5	21·5	8·45	33·90	2·00	87·36	10,800	3·56	0·05	0·07	0·90	
28·3	21·5	8·40	33·93	3·76	87·36	11,120	2·21	0·10	0·25	1·00	
28·2	21·3	8·35	33·87	4·42	89·28	10,800	2·14	0·18	0·05	0·85	
28·0	21·3	8·45	33·91	4·55	78·36	11,000	2·00	0·10	0·10	0·92	
27·5	21·3	8·40	33·77	5·52	67·61	10,920	0·70	0·25	0·18	1·00	Outside the par.
27·7	21·3	8·35	33·81	4·90	75·87	10,600	1·36	0·45	0·50	3·30	
27·4	21·3	8·40	33·77	5·72	70·28	10,880	0·70	0·08	0·10	..	
27·8	21·5	8·30	33·83	5·24	64·33	11,120	1·28	0·10	0·15	0·25	Outside the par.
..	22·5	8·45	33·85	3·38	65·00	10,000	0·70	23·80	3·40	10·20	
..	21·5	8·40	33·94	2·95	64·33	10,200	1·36	4·20	4·25	10·20	
..	21·3	8·45	33·79	3·58	65·00	10,000	0·70	23·80	3·10	8·50	
..	21·5	8·40	33·90	3·04	67·75	9,356	2·30	1·12	4·20	9·00	
..	21·3	8·45	33·70	3·25	67·80	9,922	3·00	2·80	3·10	7·80	
..	21·5	8·40	33·94	2·90	64·33	10,280	2·10	2·80	4·00	9·00	
27·8	21·8	8·40	33·98	3·72	64·75	10,400	1·25	0·70	..	0·58	
27·9	21·8	8·35	34·03	4·14	65·75	10,200	2·32	1·12	1·07	1·35	
27·8	21·8	8·40	33·93	3·92	65·75	10,140	1·70	1·40	0·05	..	
28·0	21·8	8·40	34·03	3·93	64·75	10,400	1·43	1·12	0·05	1·08	
27·9	21·8	8·35	33·93	3·52	66·75	10,200	2·70	1·12	1·00	0·70	
27·7	21·8	8·35	33·98	4·69	67·00	10,520	3·14	1·40	1·10	1·25	
27·9	20·0	8·10	25·27	2·75	78·00	8,400	14·30	1·40	3·40	2·56	
27·4	22·0	8·40	34·09	1·52	70·28	10,800	1·60	1·13	0·25	1·34	
27·9	22·0	8·35	33·98	2·48	70·28	10,520	4·60	1·69	0·89	0·40	
27·6	21·8	8·40	33·99	2·35	70·28	10,920	2·00	1·40	..	2·15	
27·6	22·0	8·40	33·01	3·74	71·45	10,800	0·72	14·08	0·71	1·34	
27·8	22·0	8·35	34·10	3·54	71·45	10,800	1·43	0·70	..	3·00	
27·7	22·2	8·40	34·22	2·69	72·30	10,720	1·25	0·70	0·75	1·05	
27·7	22·2	8·45	34·16	3·04	75·25	10,400	2·70	1·12	0·80	2·10	
27·8					No sample.						
28·0	22·2	8·40	34·22	3·73	71·75	10,880	0·90	0·70	0·80	0·85	
27·4	22·2	8·40	34·22	2·89	76·00	10,000	1·25	1·40	1·72	1·90	
27·2	22·2	8·45	34·22	4·00	70·50	11,200	0·90	8·20	5·80	9·50	
27·8	22·0	8·40	34·01	2·76	75·25	10,800	6·10	0·70	0·95	0·45	
25·5	21·8	8·45	33·88	3·00	76·00	10,240	3·04	14·08	1·80	0·63	
27·4	22·0	8·35	34·06	2·83	74·00	10,600	2·14	2·80	2·00	0·80	
27·6	22·0	8·35	34·04	2·04	75·25	10,400	1·25	4·93	2·10	1·00	
27·4	22·0	8·35	34·16	3·17	75·25	10,400	2·14	2·80	1·85	1·50	
28·0	22·0	8·40	34·16	3·59	75·25	10,400	2·14	2·20	1·90	3·90	

TABLE 4—*The physico-chemical conditions of Pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibility (meters).*	*Current.*	*Sea or swell.*
4th March 1959 *Vellungu Karuval Par*—							
Central	Surface	Blue	15·5	Flat rocky	11·5	N—S	Ripples
	Bottom	..	..	..	..	..	..
S1	Surface	Blue	15·5	Flat rocky	12·0	N—S	Ripples
	Bottom	..	..	..	..	..	..
S2	Surface	Blue	16·0	Flat rocky	12·0	N—S	Ripples
	Bottom	..				..	..
S3	Surface	Blue	16·0	Flat rocky	12·0	N—S	Ripples
	Bottom						
6th March 1959 *Vellungu Karuval Par*—							
N2	Surface	Blue	17·0	Flat rocky	12·0	N—S	Ripples
	Bottom	..		..	..		..
N4	Surface	Blue	18·0	Flat rocky	12·0	N—S	Ripples
	Bottom	..	..	..	..	..	..
9th March 1959 *Karuval Par*—							
N8—W1	Surface	Blue	16·0	Rocky with sand	12·0	N—S	Ripples
	Bottom	..	..	..	..	..	..
N8—W3	Surface	Blue	15·5	Rocky with sand	12·5	N—S	Ripples
	Bottom						..
N8—W4	Surface	Blue	16·5	Rocky with sand	12·5	N—S	Ripples
	Bottom	..	..	..	..	..	
11th March 1959 *Karuval Par*—							
N4—W2	Surface	*Blue*	*16·5*	*Rocky*	*14·0*	N—S	Swell
	Bottom	..	..	..	..	..	..
N8-W1-N1	Surface	Blue	17·0	Sand over rock	14·0	N—S	Swell
	Bottom	..	..	..	..	..	..
N8-W1-N2	Surface	Blue	16·5	Sandy	14·0	N—S	Swell
	Bottom	..	..	..	..	..	..
23rd March 1959 *Thollayiram Par*—							
N—NE10	Surface	Blue	20·0	Rocky with sand	14·5	N—S	Swell
	Bottom	..	..	..	..	..	..
N-NE8	Surface	Blue	20·0	Rocky with sand	14·5	N—S	Swell
	Bottom	..	..	..	..	..	..
N-NE6	Surface	Blue	20·0	Rocky with sand	14·5	N—S	Swell
	Bottom	..	..	..	..	..	..
24th March 1959 *Thollayiram Par*—							
N—NE4	Surface	Bule	21·0	Flat rocky	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
N—NE2	Surface	Blue	21·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
W2	Surface	Blue	19·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
W4	Surface	Blue	21·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
E1	Surface	Blue	21·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
E3	Surface	Blue	21·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
E5	Surface	Blue	23·0	Flat rocky with sand.	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
Central	Surface	Blue	21·0	Flat rocks	15·0	S—N	Ripples
	Bottom	..	..	..	..	..	..
26th March 1959 *Thollayiram Par*—							
B1	Surface	Blue	19·5	Rocky	16·0	N—S (Weak)	Swell
	Bottom	..	..	..	..	..	..
B3	Surface	Blue	20·0	Rocky	16·0	N—S	Do.
	Bottom	..	..	..	..	..	..
B5	Surface	Blue	22·0	Sandy	16·0	N—S	Do.
	Bottom	..	..	..	..	..	..

banks off Tuticorin during March 1959—cont.

Temp. °*C.*	*Sp. gr.*	*pH.*	*S°/oo.*	*Dissolved* O_2 *ml/L.*	*Excess base mg./L.*	*Calcium M. gm./L.*	*Silicate M. gm./L.*	PO_4—*P M. gm./L.*	NO_3—*N M. gm./L.*	*Iron M. gm./L.*	*Remarks.*
27·2	22·2	8·35	34·30	5·10	70·28	10,800	1·25	0·70	1·00	2·50	
28·4	22·0	8·40	34·35	5·31	70·28	10,800	1·58	1·00	1·35	4·50	
27·5	22·2	8·30	34·28	4·83	71·15	10,700	0·89	0·80	1·00	1·00	
28·5	22·0	8·35	34·32	5·04	70·28	10,800	1·50	0·95	0·75	1·50	
27·8	22·1	8·35	34·30	5·35	70·28	10,800	1·00	0·75	0·75	0·80	
28·4	22·0	8·40	34·33	5·45	67·49	10,800	1·28	0·90	1·00	1·20	
27·9	22·1	8·35	34·30	4·95	69·95	10,700	0·85	0·80	0·90	..	
28·4	22·0	8·35	34·35	5·05	67·49	10,700	1·28	1·00	1·25	1·20	
29·5	22·5	8·30	34·30	5·10	70·05	10,800	1·30	0·15	0·25	0·40	
28·6	22·0	8·30	34·35	5·04	70·05	11,000	1·30	0·30	0·50	2·40	
28·4	22·0	8·30	34·30	4·58	71·15	10,800	1·35	0·10	0·15	..	
28·2	22·0	8·30	34·35	4·51	70·05	11,000	1·40	0·20	0·25	0·35	
28·0	22·0	8·30	34·32	5·04	67·75	11,000	2·00	1·50	2·00	0·45	
29·0	21·8	8·30	34·35	4·97	67·76	10,900	1·85	1·25	1·80	0·60	
28·0	22·1	8·35	34·30	4·00	68·25	10,800	1·00	0·85	1·00	1·50	
28·8	21·9	8·40	34·35	5·35	72·18	11,000	1·18	1·20	1·20	2·50	
28·2	22·1	8·35	34·32	5·04	70·18	10,800	0·85	0·55	0·80	0·80	
28·8	22·0	8·35	34·35	4·97	70·18	10,800	1·58	0·65	0·90	1·00	
28·0	22·0	8·25	34·35	3·52	70·84	11,000	1·10	0·80	1·00	1·35	
28·5	21·9	8·30	34·42	4·00	72·28	11,120	1·80	1·20	1·50	1·85	
27·9	22·2	8·30	34·35	3·80	74·00	11,200	0·85	1·00	1·25	0·94	
28·8	21·8	8·30	34·40	3·75	72·28	11,200	1·28	0·70	1·00	0·95	
27·9	22·2	8·25	34·36	3·32	74·06	11,120	0·85	0·70	1·00	..	
28·6	22·0	8·30	34·43	3·75	72·28	11,200	0·28	0·70	0·80	0·20	
27·7	22·2	8·35	34·58	4·07	72·28	11,200	1·95	0·85	1·00	3·20	
28·7	22·0	8·35	34·51	3·93	72·28	11,200	1·85	1·00	1·25	4·80	
28·3	22·1	8·34	34·56	4·14	73·15	11,200	2·12	1·00	1·00	3·50	
38·7	22·0	8·35	34·61	4·15	72·28	11,240	1·85	1·50	1·70	3·00	
28·4	22·1	8·35	34·58	4·10	72·28	11,200	2·28	0·85	1·00	2·50	
28·6	22·1	8·35	34·61	4·15	72·28	11,240	2·50	1·00	1·40	4·50	
28·2	22·2	8·40	34·64	4·08	75·00	11,240	1·60	0·55	0·78	4·60	
29·2	22·0	8·40	34·64	4·14	72·00	11,350	1·60	0·45	0·79	2·80	
28·5	22·2	8·35	34·60	4·00	74·84	11,200	1·85	0·78	1·00	1·00	
28·9	22·1	8·40	34·48	4·28	72·02	11,200	1·60	0·75	1·00	..	
28·4	22·1	8·40	34·50	4·17	74·06	11,200	1·98	0·50	0·42	..	
28·9	22·1	8·40	34·59	3·93	70·28	11,240	1·70	0·30	0·25	1·00	
28·4	22·2	8·40	34·62	4·10	73·45	11,350	2·15	0·30	0·35	1·20	
28·8	22·1	8·45	34·52	4·13	70·28	11,350	1·90	0·15	0·25	..	
28·3	22·2	8·40	34·57	4·17	72·25	11,300	2·28	0·95	1·25	2·50	
28·9	22·1	8·45	34·52	4·07	70·20	11,240	1·90	1·00	1·25	3·00	
28·7	22·1	8·40	34·52	4·07	73·65	11,240	2·00	0·85	1·00	2·80	
28·9	22·1	8·43	34·55	4·07	70·25	11,300	2·00	1·20	1·50	3·20	
29·2	22·0	8·40	34·54	4·10	74·84	11,350	2·12	1·05	1·80	2·70	
28·9	22·1	8·45	34·58	4·15	70·28	11,350	3·10	1·55	2·25	3·50	
29·4	22·0	8·35	34·52	4·00	74·06	11,240	2·15	1·80	2·50	3·80	
28·9	22·1	8·40	34·58	4·07	70·28	11,350	3·15	2·80	3·50	10·20	
..											
29·4	22·0	8·30	34·78	4·00	72·18	11,400	1·60	0·80	1·00	1·00	
29·1	22·1	8·35	34·83	4·07	72·18	11,560	1·75	0·80	0·80	0·80	
28·8	22·1	8·35	34·83	4·07	70·28	11,560	2·00	1·00	1·00	0·35	
29·0	22·1	8·35	34·88	4·22	71·03	11,560	1·95	1·00	1·20	1·00	
28·4	22·2	8·40	34·74	4·08	72·18	11,400	3·00	0·80	1·00	2·00	
28·9	22·1	8·40	34·86	3·94	72·18	11,560	3·00	0·75	0·80	0·60	

TABLE 4—*Showing physico chemical conditions of pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibility (metres).*	*Current.*	*Sea or swell.*
30th March 1959: *Thollayiram Par*—							
C11	Surface	Blue	25·0	Sandy	18·0	S—N	Sea waves
	Bottom	..	..	..	..	..	..
C9	Surface	Do.	24·0	Do.	18·0	S—N	Do.
	Bottom	..	..	..	..	..	..
C7	Surface	Do.	20·0	Sandy with broken shells.	18·0	S—N	Do.
	Bottom	..	..	..	..	..	..
C6	Surface	Do.	20·0	Rocky with sand	18·0	S—N	Do.
	Bottom	..	..	..	..	..	..
C4	Surface	Do.	19·0	Sandy	17·5	S—N	Do.
	Bottom	..	..	..	..	..	..
C2	Surface	Do.	20·0	Do.	17·5	S—N	Do.
	Bottom	..	..	..	..	..	..

TABLE 5—*Showing physico-chemical canditions of*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibility (metres).*	*Current.*	*Sea or swell.*
2nd April 1959 : *Thollayiram Par*—							
D-1	Surface	Greenish	18·0	Sandy	12·0	S–N	Sea waves
	Bottom	..	..	..	..	..	..
D-3	Surf ace	Blue	18·0	Rocky with sandy covering.	12·0	S—N	Do.
	Bottom	..	..	..	..	..	..
D-6	Surface	Do.	19·5	Do.	12·0	S—N	Do.
	Bottom	..	..	..	..	..	..
D-7	Surface	Do.	19·5	Rocky	12·0	S—N	Do.
	Bottom	..	..	..	..	..	..
E-1	Surface	Do.	18·0	Rocky with sand	12·0	S—N	Do.
	Bottom	..	..	..	..	..	..
E-3	Surface	Do.	18·5	Rocky	12·5	S—N	..
	Bottom	..	..	..	..	..	..
4th April 1959 : *Thollayiram Par*—							
E-01	Surface	Blue	18·0	Sand (15 cm.) over rock.	11·0	SE—NW	Sea waves
	Bottom	..	..	..	..	..	..
F-1	Surface	Do.	19·0	Sandy with stray dead corals.	11·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
F-3	Surface	Do.	17·5	Do.	11·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
F-5	Surface	Do.	19·4	Rocky with 2 cm. of sand.	11·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
F-7	Surface	Do.	22·0	Sandy 25 cm. over rock	11·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
G-1	Surface	Do.	17·0	Do.	10·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
G-3	Surface	Do.	18·0	Sandy 5 cm. over rock.	10·0	SE—NW	Do.
	Bottom	..	..	..	..	..	..
G-5	Surface	Do.	18·0	Sandy 2 cm. over rock.	10·5	SE—NW	Do.
	Bottom	..	..	..	..	..	..
G-7	Surface	Do.	19·5	Do.	10·5	SE—NW	Do.
	Bottom	..	..	..	..	..	..
7th April 1959 : *Thollayiram Par*—							
H-1	Surface	Greenish	17·0	Rock with sand	10·5	S—N	Sea waves
	Bottom	..	..	..	..	..	..
H-3	Surface	Do.	18·0	Do.	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
H-5	Surface	Do.	19·5	Do.	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
H-7	Surface	Blue	22·5	Sandy over rock	11·0	S—N	Do.
	Bottom	..	..	..	..	..	..
I-1	Surface	Do.	17·0	Rocky	10·0	S—N	Do.
	Bottom	..	..	..	..	..	..
I-3	Surface	Do.	17·0	Sand over rock	10·0	S—N	Do.
	Bottom	..	..	..	..	..	..
I-5	Surface	Do.	18·0	Do.	11·0	S—N	Do.
	Bottom	..	..	..	..	..	..

banks off Tuticorin during March 1959—cont.

Temp. °*C.*	*Sp. gr.*	*pH.*	*S°/oo.*	*Dissolved* O_2 *ml/L.*	*Excess base mg/L.*	*Calcium M. gm./L*	*Silicate M. gm./L.*	PO_4—*P M.gm./L.*	NO_3—*N M. gm./L.*	*Iron M.gm./L*	*Remark.*
28·5	22·1	8·35	34·64	2·14	72·25	11,400	2·30	1·00	1·25	2·20	
29·5	21·9	8·40	34·60	2·71	71·03	11,400	2·10	1·20	1·50	2·80	
28·7	22·0	8·35	34·67	2·77	73·35	11,300	2·20	1·05	1·50	2·10	
29·5	21·9	8·35	34·60	2·71	72·18	11,500	2·00	1·75	2·50	4·00	
28·8	22·1	8·40	34·85	2·58	74·08	11,560	1·95	0·95	1·00	2·10	
29·5	22·0	8·45	34·74	2·71	73·15	11,560	1·75	0·95	1·00	1·50	
28·9	22·0	8·40	34·62	2·59	72·28	11,500	1·95	0·75	1·00	0·80	
29·6	21·8	8·40	34·57	2·46	70·25	11,400	1·80	0·50	0·80	0·30	
28·9	22·0	8·40	34·69	2·46	74·06	11,500	2·15	0·95	1·40	0·85	
29·6	22·8	8·35	34·64	2·95	72·28	11,500	1·90	0·60	1·80	0·95	
29·0	22·0	8·35	34·62	0·69	74·84	11,500	2·15	0·50	0·60	0·70	
29·6	21·9	8·40	34·64	3·47	73·31	11,500	2·00	0·20	..	0·75	

pearl banks off Tuticorin during April 1959.

28·6	22·0	8·45	34·25	3·56	72·21	11,000	2·32	0·18	0·70	1·00	
29·5	21·7	8·50	34·22	4·02	71·22	10,800	2·18	0·22	0·40	4·70	
28·5	22·0	8·45	34·31	3·47	70·89	11,000	3·04	0·14	..	0·30	
29·6	21·7	8·50	34·28	4·02	72·21	10,600	2·18	0·22	0·43	0·40	
28·8	21·9	8·45	34·28	3·70	70·89	10,680	1·88	0·18	0·40	0·70	
29·7	21·7	8·47	34·30	4·11	70·89	10,800	2·50	0·22	..	0·60	
29·0	21·8	8·45	34·28	3·64	72·21	10,880	2·00	0·14	..	0·30	
29·6	21·6	8·50	34·28	4·08	72·21	10,800	1·80	0·22	0·12	0·40	
29·4	21·9	8·45	34·30	3·15	71·22	10,800	2·00	0·16	..	0·40	
29·6	21·6	8·50	34·28	4·11	17·89	10,880	1·80	0·25	0·21	1·35	
29·4	21·9	8·45	34·32	3·88	72·21	11,000	2·18	0·15	0·09	1·20	
29·8	21·6	8·50	35·30	4·00	72·21	10,920	2·00	0·22	0·25	0·40	
29·0	21·8	8·45	34·33	2·43	68·37	11,000	1·50	0·15	..	0·50	
29·9	21·6	8·55	34·28	3·84	72·21	10,920	1·60	0·20	0·22	0·45	
29·1	21·8	8·45	34·32	3·56	69·62	10,800	1·60	0·10	..	..	
29·9	21·6	8·50	34·38	3·86	71·03	10,880	1·60	0·20	0·09	..	
29·2	21·8	8·45	34·35	3·52	69·52	11,000	1·70	0·15	0·10	0·30	
29·9	21·6	8·50	34·30	3·56	69·52	10,550	1·70	0·20	0·15	0·45	
29·2	21·8	8·50	34·45	3·37	69·52	11,000	1·60	0·10	..	..	
29·8	21·6	8·55	34·31	3·96	72·21	10,800	1·60	0·22	0·15	..	
29·1	21·8	8·50	34·35	3·71	70·28	10,450	2·00	0·12	..	..	
29·8	21·6	8·50	34·30	3·89	70·28	10,400	2·00	0·25	0·25	0·50	
29·4	21·9	8·50	34·32	3·46	79·52	10,600	2·00	0·10	..	0·30	
30·0	21·5	8·50	34·40	3·75	68·37	10,400	2·00	0·18	..	..	
29·4	21·7	8·50	34·35	3·77	69·52	10,400	1·80	0·09	0·30	0·70	
29·9	21·6	8·50	34·31	3·78	70·28	10,400	1·80	0·18	0·20	1·09	
29·6	21·6	8·50	34·28	3·77	70·28	10,320	2·00	0·10	..	0·65	
29·9	21·6	8·55	34·30	3·94	70·28	10,400	3·00	0·25	0·30	0·40	
29·3	21·8	8·00	34·30	3·78	69·52	10,400	2·70	0·08	..	..	
30·1	21·4	8·55	34·10	3·92	68·37	10,600	3·60	0·20	0·20	0·70	
29·3	21·9	8·45	34·40	3·37	70·28	10,800	1·25	0·10	..	0·50	
30·0	21·5	8·45	34·38	3·88	69·52	11,000	1·25	0·15	0·07	0·80	
29·4	21·8	8·45	34·38	3·50	70·28	10,550	1·36	0·20	0·30	0·70	
30·1	21·5	8·40	34·38	4·03	70·23	10,800	1·36	0·45	0·75	0·54	
29·6	21·8	8·40	34·36	3·31	69·52	10,000	1·25	0·50	0·64	1·35	
30·1	21·6	8·50	34·38	3·99	71·43	10,400	1·25	0·08	0·10	0·54	
29·5	21.8	8·45	34·40	3·62	79·28	10,250	1·25	0·25	0·43	0·54	
30·0	21·6	8·50	34·40	4·25	71·03	10,400	1·14	0·25	0·60	0·70	
29·6	21·8	8·45	34·42	3·45	79·52	10,400	1·36	0·36	0·80	0·54	
30·0	21·6	8·40	34·35	4·05	90·28	10,400	1·25	0·14	..	0·40	
29·7	21·8	8·45	34·42	4·15	71·03	10,300	1·25	0·30	0·45	1·08	
30·0	21·6	8·40	34·38	4·05	71·03	10,320	1·14	0·35	0·80	0·40	
29·8	21·8	8·50	34·42	3·78	70·28	10,400	1·36	0·25	0·50	0·90	
30·1	21·6	8·45	34·40	3·94	69·52	10,400	1·25	0·25	0·60	0·40	

TABLE 5—*Showing physico chemical conditions of pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibilty (metres).*	*Current.*	*Sea or swell.*
13th April 1959 : *Thollayiram Par*—							
I-0	Surface	Blue	15·0	Rock with sand	10·5	S—N	Sea waves
	Bottom	..	..	..	..	..	..
I-01	Surface	Do.	15·0	Do.	10·0	S—N	Do.
	Bottom	..	..	..	..	..	..
J-1	Surface	Do.	15·0	Do.	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
J-3	Surface	Do.	16·5	Do.	10·0	S—N	Do.
	Bottom	..	..	..	..	..	..
J-5	Surface	Do.	17·5	Do.	11·0	S—N	Do.
	Bottom	..	..	..	..	..	..
J-7	Surface	Do.	19·0	Do.	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
17th April 1959 : *Thollayiram Par*—							
K-1	Surface	Blue	17·0	Sandy	11·0	S—N	Swell
	Bottom	..	..	..	..	..	..
K-3	Surface	Do.	17·0	Rock with sand (6cm).	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
K-5	Surface	Do.	16·0	Rock with 5 *cm.* of sand.	10·5	S—N	Do.
	Bottom	..	..	..	..	..	..
K-7	Surface	Do.	18·0	20 cm. of sand over rock.	11·0	S—N	Do.
	Bottom	..	..	..	..	..	..
K-9	Surface	Do.	20·0	Sandy	11·0	S—N	Do.
	Bottom	..	..	..	..	..	..
18th April 1959 : *Thollayiram Par*—							
L-1	Surface	*Blue*	*16·0*	Sandy	10·0	N—S	Swell
	Bottom	..	..	..	..	..	..
L-4	Surface	Do.	16·0	Rock with sand	10·0	N—S	Do.
	Bottom	..	..	..	..	..	..
L-7	Surface	Do.	18·0	Do.	10·0	N—S	Do.
	Bottom.	..	..	..	..	..	..
M-1	Surface	Do.	14·0	Sandy with broken shells.	10·0	N—S	Do.
	Bottom	..	..	..	..	..	..
M-4	Surface	Do.	17·0	Rock with sand	10·0	N—S	Do.
	Bottom	..	..	..	..	..	..
M-7	Surface	Do.	20·5	Do.	9·5	N—S	Do.
	Bottom.	..	..	..	..	..	..

TABLE 6—*The physico-chemical conditions of pearl*

Station number.	*Surface or bottom.*	*Colour.*	*Depth (metres).*	*Nature of bottom.*	*Visibility. (metres).*	*Current.*	*Sea or swell.*
6th May 1959 : *Off Mannapad* (13 miles west of Mannapad point) (8°—22′ 50′ N and 78°—19′ E.)—							
1 South-West.	Surface	Blue	19·5	Rocky with sand	12·0	S—N	Sea high waves.
	Bottom	..	..	..	..	..	..
2 North-East	Surface	Do.	20·0	Rocky with sand rich in sponges and live corals.	12·0	SW—NE	Do.
	Bottom	..	..	..	..	..	..

banks off Tuticorin during April 1959—cont.

Temp. °C.	Sp. gr.	pH.	S°/00.	Dissolved O_2 ml/L.	Excess base ml/L.	Calcium U. gm./L.	Silicate U. gm./L.	PO_4—P U.gm./L.	NO_3—N U. gm./L.	Iron U. gm. /L.	Remarks.
29·6	21·8	8·40	34·48	2·46	71·43	10,400	1·25	0·25	..	0·25	
29·9	21·7	8·45	34·48	3·47	70·28	10,000	1·14	0·35	0·80	0·40	
30·0	21·6	8·40	34·49	3·48	69·52	10,400	1·25	0·15	..	0·30	
30·1	22·5	8·45	34·35	3·77	69·62	10,400	1·14	0·14	..	0·40	
30·0	21·6	8·35	34·49	3·30	70·28	10,320	1·25	0·35	0·85	0·40	
30·2	21·6	8·40	34·55	3·82	71·03	10,400	1·25	0·20	0·35	0·40	
29·9	21·6	8·35	34·48	3·77	70·28	10,320	1·25	0·24	..	0·40	
30·1	21·5	8·35	34·12	3·82	72·02	10,000	1·25	0·30	0·85	0·45	
29·8	21·6	8·40	34·40	3·77	70·28	10,320	1·14	0·14	0·30	..	
30·0	21·5	8·40	34·23	3·91	69·52	10,400	1·07	0·25	1·00	0·35	
29·5	21·8	8·40	34·27	3·78	69·52	10,320	0·90	0·10	0·77	0·30	
29·9	21·5	8·45	34·28	3·95	69·52	10,400	1·62	0·18	0·10	0·35	
30·7	21·6	8·40	34·55	3·89	70·28	10,400	1,00	0·18	..	0·30	
30·4	21·7	8·45	34·52	3·92	70·28	10,400	1·07	0·09	..	..	
30·8	21·6	8·45	34·57	3·99	70·28	10,320	1·00	0·15	..	..	
30·6	21·7	8·45	34·57	3·83	69·52	10,400	1·07	0·10	..	0·35	
30·8	21·6	8·45	34·52	3·95	70·28	10,200	1·00	0·18	0·20	0·40	
30·4	21·7	8·50	34·52	3·97	69·52	10,320	1·07	0·18	0·10	0·40	
31·1	21·4	8·45	34·55	3·95	70·28	10,400	1·00	0·15	..	0·25	
30·6	21·5	8·40	34·49	3·85	70·28	10,400	1·00	0·25	0·15	0·25	
31·1	21·4	8·40	34·40	4·03	70·28	10,200	1·00	0·18	..	0·40	
30·6	21·5	8·45	34·49	3·95	70'28	10,200	1·00	0·22	0·15	..	
30·7	21·6	8·50	34·57	4·03	70·28	11,120	0·80	1·85	0·50	0·40	
30·6	21·6	8·40	34·48	4·16	70·28	11,200	0·70	0·45	0·60	1·40	
30·8	21·6	8·45	34·60	4·22	72·18	10,800	0·80	0·10	0·47	0·40	
30·6	21·7	8·40	34·57	3·96	72·18	11,200	0·70	0·50	0·57	1·50	
30·9	21·5	8·40	34·57	4·16	72·18	11,000	0·90	0·50	0·50	0·45	
30·6	21·6	8·40	34·55	4·13	69·52	11,400	0·70	0·50	0·60	1·00	
30·9	21·6	8·35	34·60	4·16	77·03	11,400	0·90	0·40	0·36	1·50	
30·7	21·6	8·35	34·57	4·05	70·28	10,800	0·70	0·40	0·48	1·60	
31·0	21·5	8·50	34·48	4·13	72·18	11,000	0·90	0·25	0·22	2·80	
30·6	21·6	8·50	34·52	4·21	70·28	11,000	0·80	0·80	0·70	1·60	
31·4	21·5	8·30	34·57	4·13	70·28	11,320	0·90	0·45	0·43	0·32	
30·7	21·6	8·40	34·48	3·97	70·28	10,800	0·70	1·00	0·95	0·80	

banks off Tuticorin during May 1959.

Temp. °C.	Sp. gr.	pH.	S°/00.	Dissolved O_2 m /L.	Excess base mg/L.	Calcium u. gm. at/L.	Silicate u. gm. at/L.	PO_4—P u. gm. at/L.	NO_3—N u.gm. at/L.	Iron u. gm. at/L.	Remarks.
30·5	21·6	8·45	34·57	3·75	70·50	11,200	0·90	0·50	0·50	1·30	
30·2	21·8	8·50	34·52	4·20	69·00	11,000	0·90	0·20	..	..	
30·4	21·7	8·40	34·52	3·74	69·60	11,120	1·07	0·40	0·36	0·25	
30·2	21·8	8·55	34·50	3·92	69·00	11,000	1·07	0·40	0·42	0·80	

A REVIEW OF THE PHYSICO-CHEMICAL ENVIRONMENTAL CONDITIONS OF THE PEARL BANKS AND CHANK-BEDS OFF TUTICORIN IN THE GULF OF MANNAR DURING APRIL 1960-MARCH 1961.

BY

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Introduction.

The pearl-banks and chank-beds off Tuticorin in the Gulf of Mannar are productive of valuable shell.fishes. The Thollayiram par and the other pearl banks adjacent to it have yielded since 1955 an annual harvest of about 10 million oysters of remarkable pearl-content. From the chank beds about 1·0-1·20 million chanks are fished. However, no systematic information on the environmental conditions existing in these beds are available except for a few observations by Chacko and Malu Pillai (1956 and 1957) and by Chidambaram, Rajendran and Valsan (1951). Malu Pillai (under publication) has made an attempt to present a comprehensive picture of the meteorological and physico-chemical conditions of the Pearl Banks off Tuticorin. The present paper is another attempt in this direction.

Materials and Methods.

Samples of water from the pearl-banks and chank-beds were collected both from the surface and bottom normally three days in a week using Knudsen's reversible water-bottle. Zambra and Negretta Deep-Sea Reversible Thermometer (protected type) was used for temperature reading. The major meteorological elements were recorded daily, and for this the standard apparatus described by Roy (1953) were used and for the other hydro-graphical condition methods and equipments described by Harvey (1945, 1957) and Barnes (1959) were adopted. Lumeton Photoelectric colorimetre was used for colorimetre estimation of phosphate and silicate.

Maritime Meteorology.

The monthly average of temperature of the air, humidity pressure, rainfall and wind-velocity are given in Table No. 1.

The region is exposed to both the monsoons. The South-west monsoon commences by the middle of April and prevails up to September and the North-east monsoon from the middle of October to February. March and September are the transition period. The South-west monsoon was in full vigour with speed up to 45 km. but brought only 20·9 cm. of rainfall out of the total of 110·33 cm. During the peak season when the West-Coast of India, had a good precipitation, this region was dry. The North-east monsoon, although of much less vigour, brought a total of 79·48 cm. of rainfall. In November about 45 cm. of rain was recorded.

Temperature.

The atmosphere was hot with temperature between 22·0°C and 39·0°C during April to October, which was the summer period. During November-February, it was between 20·0 and 31·0°C which was the winter period. March was also hot, the atmospheric temperature exhibited 2 maxima, one in June and the other in August and similarly two minima in July and January.

Humidity.

The atmosphere was dry especially during August-September. During the South-west monsoon period it was less humid, the monthly average being 56·78 per cent. However, during the North-east monsoon period, atmosphere was humid and humidity conditions above 80 per cent observed as recorded by Paton (1936) in South and South-East Arabian sea.

Rain-Fall.

The total rain-fall during the year was 10·38. The monthly rainfall graph and humidity graph were found to be of the same pattern.

Pressure.

Pressure was normal ranging between 76·625 cm. in June and 76·740 cm. in December. Generally the pressure during the South-west monsoon season was low and during the North-east monsoon season it was high. The monthly average pressure graph was more or less of the same pattern as that of humidity.

Wind.

The wind velocity curve was a trimodal one with maxima in June, August-September and December and minima in April, July and November. The minimum in November and the maximum in January were remarkable. Velocity was comparatively much less during North-east monsoon than in the South-west monsoon.

Hydrography.

The monthly average values of the depth of the place, nature of the bottom, colour of the water, visibility, current, condition of sea, temperature, specific gravity, salinity, dissolved oxygen, excess-base, calcium, silicate-silicon and phosphate-phosphorous given in Table 2.

Temperature.

The water was warm with temperature ranging between 26·0°C in November and January and 30·5°C in May. The graph exhibited three prominent modes with peak in May, July and October. The fall in temperature during June, August and January was very sudden and deep. The water was warm from April to August and in October and March with a higher temperature invariably above 28°C. However, from November to February it was cool, and January recorded very cool waters with temperature between 26·0 and 27·3°C.

Specific Gravity.

This ranged between 23·0 in February and 25·0 in October. Generally it was high during South-west monsoon period and low during the North-east monsoon.

Hydrogen ion Concentration.

This factor was between 8·10 in May, August, November, December and 8·6 from in August to November. The average value graph exhibited a trimodal curve with peaks in May, October and March and minima in April, July and December, the decline in December being very pronounced.

Colour.

The colour of the water varied between attractive blue to greenish-blue. During July and from November to January it was more greenish indicating probably the presence of phyto-plankton.

Current.

From May to August the current was from south to north, i.e., the waters from the Arabian Sea flowing into Gulf and during April and September-March, the current was in the opposite direction, i.e., waters of the Palk Bay flowing into the Gulf. Occassional reversal of the current during August and February had also been recorded.

Conditions of Sea.

Generally the sea was disturbed. Broad and high waves were noticed during the peak of the South-west monsoon. Comparatively calm conditions existed during the other period, with occassionally very calm conditions.

Depth.

The depth of water over the pearl-banks was about 20 metres and chanks have been found even in deeper waters.

Visibility.

Visibility varied between 6·0 metres in July and 19 metres in November. Visibility was good during April-June and November-December and in February.

Nature of Bottom.

Pearl banks are of calcite rock with 25–57 mm. Overlayer of sand and shell grit were also noticed in certain places. The chank-bed are sandy and of coarse sand without any mud.

Salinity.

This ranged between 32·07 per cent in November and 35·91 per cent in September and was high in South-west monsoon months of August-September and in October and very low during North-east monsoon months of November to February. Lowest values were observed during December.

Dissolved Oxygen.

Varied from 6·84 cc./1 in October to 3·4 cc./1 in September. Oxygen super-saturated water was also recorded. The graph exhibited trimodal curve with distinct peaks in June-October and January and declines in April, September and November. During the North-east monsoon months, the oxygen saturation was more and during the South-west season it was less.

Silicate.

Wide and sudden variations between 90 mg.m/1 in March and traces (in October and January) were recorded. During June-July, November-December and February-March it was high and during August-September, October and January it was less.

Phosphate.

Sudden fluctuations between 8 m.gm./litre in June and nil during August to December and again in February, March were the features of variation in phosphate. Complete absence of phosphate was frequently met with during the above period. Generally phosphate was rather low. During the South-west monsoon period when the current was from south and north, phosphate was fairly rich. However, during the North-east monsoon period paucity of this nutrient was frequently met with.

Alkalinity or Excess Base.

No remarkable variations could be observed during the period. The variation was between 67·5 mg./1 in November and 71·5 mg./1 from July to November. The alkalinity was high throughout except for the slight fall in May and December.

Calcium.

The calcium content varied between 10,490 mgm/1 *in November and 12,930 mgm. /1 in October.* The average Calcium content graph indicated three modes with maxima in June, September and December and minima in April, August and November. There was a tendency to form yet another peak with maximum in March and minimum in January.

General Conditions of Plankton.

Fish eggs and larvae were commonly seen during August-October. Zoo-organisms like *copepods*, *ceratium* and *Sagitta* were predominating during the period. Phyto-organisms in August and from October to February. Although phyo-planktonic organsims like *Coscinodiscus*, *Biddulphia Chaetoceros*, etc. were common, *Noctiluca* bloom was observed in October. Planktonic peak was observed in December also.

Discussion.

The prevailing two monsoons seemed to have a very great effect on the major meteorological and hydrographical factors. The sudden drop in the temperature of the atmosphere during July was attributable to the high humidity and precipitation. The abnormal lowering in temperature during November to February was again attributable to the strong wind, high humidity and precipitation. The pressure was high during November and December when humidity of the air and precipitation were also high.

The surface temperature graph is of the same pattern as the atmosphere temperature graph during the South-west monsoon period, but the periods of maximum surface temperature preceded the corresponding maximum of the atmosphere. But during the peak North-east monsoon period, the graphs were more or less alike. During August-September reverse conditions were noticed. This was probably due to the sudden increase in the wind velocity and the reversal of the current system when cold water from the Palk Bay flowed into the Gulf.

The sudden decrease in salinity during June in spite of the South-north current may probably be due to the effect of heavy rain in the South and South-east Arabian Sea and in the catchment area of river Tambaraparni. The high salinity during August to October might be due to evaporation caused by the sudden increase in the wind velocity and due to the high atmospheric temperature. The remarkable lowering during the North-east monsoon is due to the inflow of fresh water.

The abnormal lowering of pH value during December might be due to the influx of fresh water. Supersaturation of oxygen was indicative of greater photo-synthesis due to the presence of thick phyto-plankton, nanno-plankton. Low oxygen in April-May and in September was suggestive of greater rate of respiration than photo-synthesis.

Greater utilisation of silicate during April-May, September-October and in December-January might probably be for the formation of silicious exo-skeletons of the diatoms. The abnormally high concentration of silicate during November and February-March might be due to the dissolution of excreta of the diatom grazing copepods and other organisms which were in peak and the dissolution and decomposition of the diatoms themselves.

Low phosphate content almost throughout the year was suggestive of a good standing crop, especially from July onwards. The high oxygen concentration inspite of zoo-organisms throughout the year indicated that the water was fertile but the nutrients like phosphate are absorbed by phyto and nanno-planktonic organisms. The increase in salinity following lowering and the slight fall in temperature give the impetus for the off-shoot of phyto-organisms. The rich pasture grounds provided, following the off-shoot of plankton would give the necessary impetus for fishes to breed. This as well as the oceanic salinity and slightly low temperature would even be responsible for a shore-ward migration of certain pelagic fishes. Greater utilisation of Calcium during April-May was suggestive of spat-fall during that period. High calcium in June-July and in September may be due to the dissolution of calcium carbonate forming the ooze and dead calcareous organisms or due to the influx of fresh water rich in calcium.

The absence of effective vertical gradient of temperature, salinity, or oxygen was suggestive of a good mixing up of the water.

It might be said that the water of the pearl-banks would be fairly warm, highly saline and rich in calcium. The water was rich in dissolved oxygen and it substained a good standing crop and nanno-plankton organisms which form the food of the pearl oysters.

Summary.

(1) Meteorological and hydrographical conditions of the pearl-banks off Tuticorin are brought out and discussed.

(2) The profound effect of the current systems caused by the two monsoons are discussed.

(3) The shore-ward migration of certain pelagic fishes are indicated.

(4) Season of spat-fall of pearl oysters has been suggested.

(5) Good vertical mixing of waters is established.

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TABLE 1.—*Maritime Meteorology of the Tuticorin Bay during April 1960 to March 1961.*

Month.	*Temperature °C.*			*Humidity.*			*Pressure (cm.).*			*Rain fall. (cms.)*	*Wind.* *Direction.*	*Speed KM/hr.*		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	MAX.	MIN.	AVER.	MAX.	MIN.	AVER.	MAX.	MIN.	AVER.		Between	MAX.	MIN.	AVER.
April	38·0	23·0	29·63	100	60	77·68	76·625	76·100	76·343	12·2	SW-N and SE ..	45	..	8·0
May	38·0	24·0	30·30	90	45	68·25	76·325	76·100	76·176	4·4	W, S. and ENE	32	3	12·4
June	39·0	25·0	31·80	75·0	53·0	61·0	76·250	76·025	76·157	..	W, S, SW ..	38·2	3	21·3
July	36·0	23·0	28·03	95	50	62·58	76·275	76·100	76·190	2·9	W, S and N ..	38·2	3·2	16·99
August	37·0	22·0	30·5	80	40	58	76·370	76·100	76·161	..	NW, WSW and ENE.	42·2	3·2	19·4
September	37·0	24·0	30·10	90	50	59·8	76·325	76·075	76·191	1·4	W, W, SW and N	35·2	3·2	19·4
October	36·0	22·0	28·13	100	45	73·4	76·575	76·125	76·300	15·4	WSW, NW and NE.	22·4	6·4	12·7
November	31·0	22·0	26·0	100	70	86	76·575	76·345	76·478	45·1	SW, N and SE ..	16·9	3·2	8·4
December	30·0	20·0	25·5	95	70	81	76·740	76·330	76·530	2·98	NNW, N and SSE	29·2	3·2	16·95
January 1961	30·0	20·0	24·9	95	70	85·5	76·685	76·435	76·596	15·6	WNW, N and ENE	22·13	10·5	15·4
February	30·0	21·0	25·94	90	60	79·82	76·675	76·350	76·493	..	NNW, N, NNE	26·14	0·0	13·15
March	35·0	23·0	27·45	100	65	81	76·700	76·315	76·520	0·4	SW, NNE and N.	22·12	3·5	12·7

TABLE 2—*The Physical Factors of the Pearl Banks off Tuticorin during April* 1960—*March* 1961.

Month.	*Locality.*	*Colour.*	*Current.*	*Sea or swell.*	*Depth (m.).*			*Visibility (m).*			*Nature of bottom.*
(1)	(2)	(3)	(4)	(5)	(6) MAX.	(7) MIN.	(8) AVER.	(9)	(10)	(11)	(12)
April	Thollayiram par	Attractive or Greenish blue.	N–S	Waves	19	18	18·8	16·5	15·0	15·7	Par with sand and shell grit.
May	Do.	Light blue	SE–NW	Broad waves.	19	18	18·5	15·0	13·0	13·5	Do.
June	Thollayiram par and Koothadiar par.	Light blue to bluish green.	SE–NW	Broad waves.	19	18	18·3	15	13	13·9	Do.
July	Thollayiram par and Karai par.	Greenish blue.	S–N	Waves (High).	18	14	17·0	10	6	7·3	Do.
August	Thollayiram par	Bluish or fine green.	SE–NW on 2 days N–S.	Broad waves.	19	15	18·0	14·0	8·5	12·2	Do.
September	Do.	Bluish	N–S	Swells and waves.	20	18	18·5	13	12·0	12·7	Do.
October	Thollayiram par Koothadiar par Pasi par, Patharai par.	Bluish or greenish	N–S	Waves and swells.	19	17	18·0	13	10·5	12·5	Do.
November	Thollayiram and Karaikalathi par.	Greenish and bluish.	N–S	Swell waves.	19·0	17·0	17·5	19	12·0	13·0	Do.
December	Thollayiram par.	Blue	N–S	Swells	21·0	18·0	19	14	13	13·7	Par with fine sand scattered oysters and fish.
January	Thollayiram par, Karai par, Kothadiar par.	Green and blue.	W–S	Waves	19	14	17	10·5	8·0	9·5	Par with sand and shell grit.
February	Thollayiram par.	Attractive blue.	S–N and N–S	Waves	19·0	16·0	17·5	14·0	13·0	13·75	Do.
March	Do.	Attractive blue or green.	N–S	Swells	20·0	16·0	18	16	15	15·3	Par with little sand and good population.

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TABLE 3—*The Physico Chemical Factors of the Pearl Banks off Tuticorin during April 1960—March 1961.*

Temperature °C,			Specific gravity,			pH,			Salinity (%).			Dissolved oxygen cc/L,		
MAX,	MIN,	AVER,	MAX,	MIN,	AVER,	MAX.	MIN,	AVER,	MAX,	MIN.	AVER,	MAX.	MIN,	AVER,
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
30·3	29·5	29·98	24·3	24·1	24·2	8·4	8·1	5·30	34·50	34·15	34·37	3·80	3·52	3·63
30·5	29·3	30·1	24·3	24·1	24·2	8·55	8·30	8·45	34·90	34·52	34·77	3·92	3·52	3·75
29·3	28·0	28·7	24·6	23·4	23·8	8·40	8·30	8·35	35·25	33·45	33·98	4·7	4·2	4·53
29·9	28·0	29·45	24·3	24·2	24·30	8·45	8·1	8·3	35·5	34·86	34·99	4·75	4·25	4·51
30·2	26·5	27·87	24·7	24·3	24·6	8·6	8·2	8·45	35·41	35·33	35·39	4·90	4·00	4·40
29·1	26·8	27·8	24·8	24·3	24·60	8·6	8·45	8·50	35·9	35·30	35·43	4·80	3·40	3·94
28·8	27·0	28·1	25·0	29·8	24·83	8·6	8·45	8·54	35·59	34·92	35·26	6·84	4·23	4·96
28·7	26·0	27·9	24·6	24·5	24·52	8·6	8·1	8·5	35·08	32·07	33·40	5·79	4·18	4·84
28·0	27·5	27·8	24·0	23·8	23·9	8·1	8·1	8·1	33·31	32·16	32·55	5·04	4·60	4·89
27·2	26·0	26·45	24·0	23·7	23·7	8·5	8·3	8·4	33·63	32·15	32·93	5·47	5·18	5·40
27·5	27·0	27·2	23·0	23·0	23·0	8·5	8·3	8·40	33·59	32·84	33·31	4·86	4·75	4·78
28·5	28·2	28·3	23·2	23·2	23·2	8·5	8·4	8·43	33·82	33·53	33·60	5·14	4·67	4·86

TABLE 4.—*The excess base and nutrients of the Pearl Banks off Tuticorin during April 1960—March 1961.*

Excess base mg/L,			Calcium per gram atom/L,			Silicate—Silicon per gram atom/L,			Phosphate—Phosphorus per gram atom/L,		
MAX.	MIN.	AVER.	MAX.	MIN.	AVER.	MAX.	MIN.	AVER.	MAX.	MIN.	AVER.
70·5	70·0	70·2	11,200	10,600	10910	6·5	2·5	4·9	2·0	Trace.	Trace.
70·0	69·5	69·75	11,200	10,900	11030	12·5	4·5	8·9	3·5	2·0	2·6
70·5	69·5	70·0	12,200	11,710	12080	22·5	10·0	17·2	8·0	3·0	6·0
71·5	69·5	70·3	12,200	11,710	11,940	30	12·5	19·0	3·0	Trace.	1·3
71·5	70·5	70·8	12,690	10,500	11,520	25	6·2	11·8	5·5	..	2·1
71·5	69·5	70·4	12,780	12,200	12,600	8·0	3·0	5·7	2·0	..	Trace.
71·5	70·8	71·1	12,930	11,710	12,240	15·0	Trace.	5·4	1·5	..	0·42
71·8	67·5	70·62	12,200	10,490	11,390	6·5	6·0	17·8	3·0	..	·70
68·5	68·5	68·5	11,810	11,480	11,630	20	18	19	2·5	..	Trace.
70·5	69·5	70·0	11,710	10,980	11,500	18·0	Trace.	7·0	3·0	Trace.	Trace.
70·5	69·5	70·30	12,110	10,740	11,620	80	28	49	6·0	Nil.	1·3
71·5	70·5	70·8	12,450	11,710	12,000	90	25	48	3·5	..	1·0

HYDROBIOLOGY AND FISHERIES OF THE ENNORE RIVER NEAR MADRAS FROM APRIL 1960 TO MARCH 1961.

BY

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The Ennore river estuary is situated about eleven miles north of Madras City. It is 1½ miles long and 4 furlongs wide and 3–5 feet deep on the average. The Buckingham Canal runs through it. Its bottom is muddy with an admixture of sand. The sea opens into it by a bar which occasionally closes.

This estuary is a good source of fisheries, particularly of mullets and prawns. Extensive beds of the edible oyster, *Ostrea madrasensis*, also occur in it and the adjoining backwaters. Studies on the hydrobiology and fisheries of this water area are therefore being pursued regularly at the Fisheries Biological Station at Ennore. In this note the salient features of observations made during the period 1st April 1960 to 31st March 1961 are given.

The bar of the estuary remained open with the sea from the beginning of 4th November 1960 to the end of the year. There was a total rainfall of 42·15 inches during the year spread over six months, 27·29 inches being in October. The maximum humidity was 96 per cent in January and March and the minimum 51 per cent in June. It averaged 78 per cent in June and 93 per cent in March. The atmospheric temperature attained a maximum of 36·5°C in May and minimum of 24·0°C in November. The surface temperature of the estuary-water showed a corresponding fluctuation, the maximum being 35°C in June and minimum 23·5°C in November. Coinciding with this, the specific gravity was noted to increase to 1·028 in July and August and decrease to 1·000 in November. The pH ranged between 8·9 in May and 7·4 in November. Higher salinity of 39·32–46·7 parts per 1,000 was observed during the months when the estuary had no connection with the sea. The minimum salinity was 0·2 °/oo in November. Details are given in tables I and II.

Regular hauls of plankton were made from the estuary and analysed quantitatively and qualitatively. The sedimentation ranged from 1 to 500 cc per haul of 1 litre made in 20 minutes. The diatoms *Coscinodiscus* and *Rhizosolenia* were fairly common almost throughout the year. Among zoo-plankton, copepods and their nauplii were very common throughout the year. Larval prawns were noted from June to November in large numbers. Fish eggs were present in fair number from June to September. *Leucifer* appeared in April and November. *Zoea and Megalopa larvae were noted in* November, December and January. The fluctuation of 35 organisms on the whole is given in table III.

The trend of the fisheries of the estuary was interesting. The total landings during the year were about 255 tons. Mullets particularly *Mugil cephalus and M. dussumieri* formed the bulk of the catches, being about 40 per cent of the total catches. Cat fishes, Silver bellies (*Leiognatus spp*) horse mackerals, Gizzard shad, Whiting, *Etroplus*, *Therapon* and *Gerres* were the other main fisheries. *Chanos chanos*, *Elops saurus*, *Polynemus*, *Teuthis* and Jew fishes were present in smaller numbers almost throughout. Prawns and crabs wre present throughout the year, but only formed 5·0 and 2·5 per cent of the total catches. *Statistical details are given in Table IV.*

TABLE I—*Meteorological data for the year* 1960–61 (*Ennore*).

Month.	*Atmospheric temperature °C.*			*Humidity per cent.*			*Atmospheric pressure, inches.*			Rain inches.
	Maximum.	*Minimum.*	*Average.*	*Maximum.*	*Minimum.*	*Average.*	*Maximum.*	*Minimum.*	*Average*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
April	33·0	32·5	32·75	88	62	76	1·022	1·019	1·021	Nil.
May	36·5	29·0	32·75	86	62	74	1·010	1·008	1·009	Nil.
June	35·5	29·0	32·25	74	51	68	1·010	1 003	1 007	0.35
July	34·0	28·5	31·25	80	62	71	1·006	1·003	1·004	1·19
August	33·0	29·5	31·25	80	60	74	1·008	1·003	1·006	Nil.
September	35·0	26·5	30·75	93	65	79	1·008	1·004	1·006	7·69
October	37·0	28·0	30·5	89	68	78·5	1·025	1·007	1·020	5·24
November	32·0	24·0	28·0	95	59	77	1·020	1·010	1·015	27·29
December	29·5	24·5	27·0	93	67	81·5	1·016	1·014	1·015	Nil.
January	31·5	26·5	29 0	96	67	81·5	1·016	1·014	1·015	Nil.
February	32·0	26·5	29·25	91	76	83·5	1·014	1·009	1·012	0·39
March	32·5	28·5	30·5	96	90	93	1·015	1·009	1·012	Nil.

TABLE II—*Hydrography of Ennore Estuary* (1960–61).

Months.	*Surface temperature °C.*			*Specific gravity.*			*PH value.*			*Salinity. p.p. 1000.*		
	Maximum.	*Minimum.*	*Average.*	*Maximum.*	*Minimum.*	*Average.*	*Maximum.*	*Minimum.*	*Average*	*Maximum.*	*Minimum.*	*Average.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
April	29·0	28·0	28·5	1·022	1·018	1·000	8·7	8·2	8·4	43·4	40·0	41·7
May	34 0	28·0	31·0	1·026	1·022	1·024	8 9	8·2	8·5	44 8	41·5	41 15
June	35·0	27·5	31·25	1·027	1·002	1·025	8·6	8·0	8·3	46 7	38·6	46·67
July	32 5	28·5	30·5	1·028	1·025	1·027	8·7	8 0	8·2	40 3	35·03	37·7
August	32·5	27·5	30·5	1 028	1·024	1·026	8·4	8 2	8·3	39·32	35·88	37·6
September	33·0	26 0	20·5	1·026	1·018	1 018	8·4	8·7	8·1	36 84	14·89	25·8
October	32·5	27·5	30·0	1·012	1 008	1·010	8·4	8 0	8·2	20·80	14·21	17·5
November	30·5	23·5	27 0	1 010	1·000	1·005	8·4	7·4	7·9	18·54	0·223	9·3
December	29·0	24·5	26·75	1·018	1 002	1·010	8·4	7·0	8·2	20·82	14 02	17·4
January	29·0	26·5	27·75	1·020	1 010	1·015	8·4	8·0	8·2	26·44	17·32	21·9
February	29 5	26·5	28 0	1·022	1·008	1 020	8 4	8·0	8·2	26·92	26·44	26·7
March	30·0	28 0	29·0	1·024	1 020	1·022	8·4	8·0	8·2	28·40	27·32	27·9

TABLE III—*Plankton report for the year* 1960–61 (*Ennore Estuary*).

	Apr.	*May.*	*June.*	*July.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*
Phytopllankton—												
1 Rhizosolenia	F	F	F	F	F	F	F	P	R	..	S	..
2 Navicula	R	..	..	..	..	..	..	..	..	..	..	..
3 Asterionella	R	..	..	..	..	..	..	..	..	..	..	..
4 Chaetoceros	R	..	..	F	..	..	..	..	..	..	..	R
5 Coscinodiscus	..	..	F	..	..	..	F	F	F	..	F	F
6 Thallassiothrix ..	..	..	..	..	..	..	..	R	..	..	..	..
7 Biddulphia ..	..	..	..	..	..	..	..	R	..	R	..	R
8 Oscillatoria	..	..	..	..	..	..	..	..	..	..	F	R
9 F.W. Algal filament.	..	..	..	..	..	..	..	R	..	..	F	R
Zooplankton—												
10 Foraminiferan shells.	R	..	..	..	..	..	..	..	..	..	..	R
11 Ceratium	R	P	R	R	F	F	..	..	..	F	..	R
12 Noctiluca	..	..	..	..	..	..	..	..	..	..	..	R
13 Tintinnus	..	F	F	F	C	F	..	F	F	F	S	S
14 Rotifers	P	S	C	R	S	..	..	..	..	F	P	R
15 Medusoids	..	..	..	..	R	F	F	..	..	..	..	..
16 Pleurobrachia ..	..	..	..	..	..	..	..	..	..	..	..	S
17 Prototrochophore ..	..	..	..	..	R	..	..	..	..	F	..	R
18 Metatrochophore ..	..	..	F	F	F	..	..	..	..	..	..	..
19 Polychæte larvæ ..	R	..	F	..	..	F	..	R	P	P	R	R
20 Larval Bivalves ..	F	..	..	..	..	..	S	F	F	F	F	..
21 Larval Gastropods ..	F	F	P	P	P	C	C	F	..	..	..	..
22 Nauplii	F	R	P	F	C	P	P	S	F	F	F	F
23 Ostracods	..	..	..	..	F	..	..	..	..	..	..	..
24 Copepods	C	S	S	S	S	S	S	S	S	S	C	F
25 Leucifers	R	..	..	..	..	..	..	C	..	..	..	..
26 Mysis	R	..	..	..	..	..	..	..	..	..	..	..
27 Isopods	..	..	..	..	..	..	..	..	..	..	R	..
28 Amphipods	..	..	..	..	..	..	..	R	..	F	F	..
29 Young prawns ..	..	R	C	S	S	S	S	S	R	R	..	R
30 Zoea larvæ	..	..	..	..	..	..	..	..	..	C	..	R
31 Megalopa larvæ ..	..	..	..	..	..	..	..	C	C	..	..	R
32 F.W. Insects	..	..	..	..	..	..	..	..	R	..	..	..
33 Oikopleura	..	..	..	..	..	..	..	..	..	R	..	..
34 Fish eggs	R	..	F	F	C	F	..	..	..	..	..	R
35 Larvae of fishes ..	R	..	..	..	..	..	..	R	..	R	..	..

NOTE.—R=10–30 individuals per CC; F=30–200 per CC; C=200–400 per CC; P=400–1,030 per CC; and S=More than 1,000 per CC.

TABLE IV—*Fishery Statistics of the Ennore Estuary for the year 1960–61.*

Month.	*Mullet.*	*Gerres.*	*Sillago.*	*Therpon.*	*Caranx.*	*Chanos.*	*Equula.*	*Hemirамphus.*	*Etroplus.*	*Catfish.*	*Scolopsis.*	*Priacanthus.*	*Chatoessus.*	*Engraulis.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
April	8,480	4,000	4,492	4,246	6,246	2,000	4,246	6,488	4,200	4,292	2,130	4,250	6,500	3,800
May	6,310	640	562	470	5,364	492	2,692	2,600	2,764	4,038	1,640	3,220	4,772	1,000
June	21,200	1,309	5,115	800	1,309	775	2,311	197	218	1,233	615	736	424	1,194
July	18,650	3,230	2,037	3,068	3,039	2,050	3,198	2,260	2,076	6,460	2,900	2,230	2,200	2,086
August	6,442	3,000	4,221	2,325	4,226	2,800	3,426	4,988	3,000	5,638	3,254	2,376	5,639	1,195
September	8,090	2,673	2,863	2,500	3,545	1,876	1,160	2,033	3,900	3,874	2,545	2,045	4,690	..
October	62,546	418	280	4,100	5,090	1,120	11,250	520	216	8,286	1,418	2,196	2,243	3,548
November	22,000	232	236	286	..	..	2,692	250	200	3,500	189	2,190	..	960
December	21,563	200	2,350	70	..	450	2,300	185	450	2,955	200	1,160	1,300	1,150
January	12,830	350	2380	2,112	5,080	1,126	5,750	1,000	1,868	3,075	760	2,000	3,200	1,460
February	18,000	2,500	1,887	1,456	1,950	650	2,190	425	2,230	2,920	420	1,324	1,500	210
March	12,950	1,625	924	389	6,432	1,075	2,360	820	968	2,867	756	1,583	2,364	1,326
	2,19,061	20,077	27,347	21,822	41,281	14,412	43,675	21,766	22,035	49,133	16,827	25,310	34,832	17,919

Month.	*Pristopoma.*	*Polycanthus.*	*Sciaena.*	*Teuthis.*	*Lutjanus.*	*Engraulis.*	*Elops.*	*Polynemus.*	*Flat fish.*	*Ambassis.*	*Miscel.*	*Prawn.*	*Crab.*
	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
April	2,480	..	..	..	..	..	..	..	..	..	2,094	4,312	1,700
May	2,040	..	..	1,960	..	..	..	..	..	..	1,390	4,764	1,600
June	675	..	..	1,310	..	..	..	..	..	..	1,206	946	953
July	3,183	2,065	2,070	..	..	..	1,250	..	..	..	2,860	2,215	3,048
August	2,876	..	3,889	..	..	3,021	.	..	..	..	210	4,892	689
September	1,720	525	2,000	521	..	..	2,640	937	..	..	1,246	3,546	1,730
October	..	2,060	2,200	1,066	..	..	1,085	..	10	..	2,064	1,400	50
November	..	100	360	..	..	..	180	550	95	629	..	2,676	1,778
December	..	..	245	665	100	..	200	300	..	..	500	465	54
January	1,850	..	1,050	..	..	..	589	..	..	..	1,500	3,846	500
February	915	564	790	..	422	366	400	..	150	..	920	1,060	379
March	..	1,732	1,935	..	1,100	..	1,750	..	883	..	736	1,685	547
	15,739	7,946	14,539	4,922	1,622	3,381	8,074	1,787	1,138	629	14,966	31,507	14,068

SIZE AND SEX COMPOSITION OF CATCHES OF THE LOBSTER PANULIRUS DASYPUS (LATREILLA) ALONG KANYAKUMARI DISTRICT COAST IN 1960-61.

BY

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Introduction.

An account of the fishery of the lobster occurring in the coastal waters of Kanyakumari district has been given by Balasubramanyan (1960) and Ramanadan & Chacko (1962). The fishery of that rocky dwelling crustacean is lucrative to the local fisherfolk as the lobster 'Tails' are deep frozen and exported to the United States of America. In 1960–61, the fishery started in the second week of December 1960 and lasted till the end of March 1961. During the period about 400,000 lobsters were captured. The sex and size composition of these were studied as given below :—

Sex Composition.

The details of the composition is given in Table I. Males predominated being 60·44 per cent when compared to 39·56 per cent of females. Almost all males were adults and only 1·36 per cent among them were immature. Of the females, 94·08 per cent were adults and 5·94 per cent were immature ; and 53·14 per cent were "berried" and 54·39 per cent possessed sperm-packets. Thus there was intensive spawning during the period.

Size Composition.

The details of the size composition are given in Table II. The size groups, based on the length of the carapace were from 5–12 cm. of which 6—8 cm. groups constitute the bulk of the fishery. Males were represented in all the size groups, sizes 10–12 cm. being all males. On the contrary, females were confined to 5–9 cm. groups and they being totally absent in the higher size groups.

Discussions.

The fishery in 1960–61 was slightly better than in 1959–60, when the total number of lobsters fished was only between 3 to 4 lakhs. However, mature individuals in stages of breeding continued to contribute to the bulk of the fisheries. These features may have an adverse effect on the future fisheries of these important Crustaceans. This aspect is however being watched by the Department.

Acknowledgment.

I am thankful to Sri P. I. Chacko, Assistant Director of Fisheries, for his guidance and for his valuable suggestions.

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TABLE I—*Showing sex composition of Lobsters caught during* 1960–61.

	Percentage in total number examined.	*Percentage in total number of particular sex.*
Male lobsters	60·44	..
Male adults	59·62	98·63
Male immature	0·82	1·37
Female lobsters	39·56	..
Female adults without berry or sperm packet.	10·90	27·26
Female berried ..	21·26	53·14
Female with sperm packet.	21·76	54·39
Female with sperm packets and without berries.	5·02	12·54
Female immature	2·38	5·94
Female adult including berried ones.	37·18	94·06

TABLE II—*Showing composition of different size groups (Carapace length) of Lobsters caught during* 1960–61.

Size group, cm.	*Percentage of group in total examined.*	*Percentage of males.*		*Percentage of females.*			
		Adults.	*Immature.*	*Berried.*	*With sperm packets.*	*Adult without berried or sperm packets.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5	7·71	39·65	1	0·6	0·12	17·75	30·77
6	22·95	51·09	2	18·4	14·80	23·6	..
7	36·86	56·68	..	31·1	32·25	6·43	..
8	24·36	68·00	..	21·5	21·91	6·18	..
9	6·16	89·00	..	6·60	5·90	4·44	..
10	1·87	100·00	..	..	..	..	..
11	0·04	100·00	..	..	..	..	..
12	0·045	100·00	..	..	..	..	..

PISCIVOROUS BIRDS OF MADRAS

BY

H. K. GHAZI.

This list includes piscivorous birds, oceanic birds, shore birds, aquatic birds and predators and other birds which feed on fishes and other aquatic forms generally or occasionally.

Class—Aves.

Sub-class—Neornithes.

Order—Podicipediformes.

Family—Podicipedidae.

Podiceps ruficollis capensis.

Order—Procellariiformes.

Family—Procellariidae.

Daption capensis.
Procellaria leucomelaena.
Procellaria carneipes.
Procellaria pacifica chlororhyncha.
Procellaria tenuirostris.
Procellaria lherminieri bailloni.
Procellaria lherminieri persica.

Order—Pelecaniformes.

Family—Phaethontoidae—

Phaethon aethereus indicus.
Phaethon rubricauda rubricauda.
Phaithon lepturus lepturus.

Family—Pelecanidae—

Pelecanus onocrotalus roseus.
Pelecanus philippensis philippensis.

Family Sulidae—

Sula dactylartra melanops.
Sula sula rubripes.
Sula leucogasher plotus.

Family—Phalacrocoracidae—

Phalacrocorax carbo sinensis.
Phalacrocorax fuscicollis.
Phalacrocorax niger.
Anhinga rufa melanogaster.

Family—Fregatidae—

Fregata andrewsi.
Fregata miner oldabrensis.
Fregata ariel iredalei.

Order—Ciconiiformes.

Family—Ardeidae—

Ardea goliath.
Ardea cinerea rectirostris.
Ardea purpurea manilensis.
Buteroides striatus javanicus.
Ardeola grayii.
Bubulcus ibis coromandus.
Egretta alba modesta.
Egretta intermedia intermedia.
Egretta garzetta garzetta.
Egretta gularis schistacea.
Nycticorax nycticorax nycticorax.
Garsachius melancphus melanophus.
Ixobrychus cinnamomeus.
Ixobrychus sinensis sinensis.
Dupeter flavicollis flavicollis.
Botaurus stellaris stellaris.

Family-Ciconiidae—

Ibis leucocephalus.
Anastomus ascitans.
Ciconia episcopus episcopus.
Ciconia ciconia ciconia.
Ciconia nigra.
Xenorhynchus asiaticus asiaticus.
Leptoptilos dubius.
Leptoptiles javanicus.

Family Threskiornithidae—

Threskiornis melanocephala.
Pseudibis papillosa papillosa.
Plegadis falcinellus falcinellus.
Platalea leucordia major.

Family—Phoenicopteridae—

Phoenicopterus roseus.

Order—Anseriformes.

Family—Anatidae—

Anser anser rubrirostris.
Anser indicus.
Dendrocygna javanica.
Dendrocygna bicolor.
Tadorna ferruginea.
Anas acuta.
Anas crecca crecca.
Anas poecilorhyncha poecilorhyncha.
Anas strepera strepera.
Anas penelope.

Anas querquedula.
Anas clypeata.
Rhodonessa caryophyllacea.
Netta ruffina.
Aythya ferina.
Aythya nyroca.
Aythya fuligula.
Nettapus coromandelianus coromandelianus.
Sarkidiornis melanotos melanotos.

Order—Falconiformes.

Family—Accipitridae—

Elanus caeruleus vociferus.
Aviceda jerdoni ceylonensis.
Aviceda leuphotes leuphotes.
Aviceda leuphotes syama.
Pernis ptilorhynchus orientalis.
Pernis ptilorhynchus ruficollis.
Milvus migrans govinda.
Haliastur indus indus.
Accipter badius dussumieri.
Accipiter badius badius.
Accipiter trivirgatus peninsulae.
Accipiter nisus nisosimilis.
Accipiter virgatus besra.
Buteo vulpinus vulpinus.
Buteo buteo burmanicus.
Butastur teesa.
Spizaetus vipalensis Kelaarti.
Spizaetus cirrhatus cirrhatus.
Spizaetus cirrhatus ceylanensis.
Nisaetus fasciatus fasciatus spiza.
Heiraaetus pennatus.
Lophotriorchis Kienerii Kienerii.
Aquila clanga.
Aquila impalensis impalensis.
Aquila pomarina hastata.
Ictinaetus malayensis perniger.
Haliaeetus leucogaster.
Icthyophaga icthyaetus icthyaetus.
Icthyophaga icthyaetus plumbeiceps.
Tergos calvus.
Gyps indicus indicus.
Gyps bengalensis.
Neophron percnopterus gingionianus.
Circus cyaneus cyaneus.
Circus macrourus.
Circus pygarus.
Circus melanoleucos.
Circus aeruginosus aeruginosus.
Circaetus gallicus gallicus.
Spilornis cheela melanotis.
Spilornis cheela spilogaster

Family—Falconidae—

Falco biarmicus jugger
Falco peregrinus japonensis
Falco peregrinus peregrinator
Falco severus rufipedoides
Falco chiquera chiquera
Falco vespertinus amurensis
Falco naumanmi pekinensis
Falco tinnunculus tinnunculus
Falco tinnunculus interstinctus
Falco tinnunculus objurgatus

Order—Gruiformes.

Family — Gruidae—

Grus grus lilfordi
Grus antigone antigone
Anthropoides virgo

Family—Rallidae—

Rallus aquaticus indicus
Rallus striatus albivanter
Rallina eurizonoides amauroptera.
Porzana pusilla pusilla
Porzana porzana
Amaurornis fuscus zeylonicus
Amaurornis akoolakool
Amaurornis phaenicurus chinensis
Amaurornis phoenicurus phoenicurus
Gallicrex cinerea cinerea
Gallinula chloropus indica
Porphyrio porphyrio poliocephalus
Fulica atra atra

Family—Otididae—

Chloriotis nigriceps
Sypheotides indica

Order—Chardriiformes.

Family—Jacanidae—

Metopidius indicus

Family—Haematopodidae—

Haematopus ostralegus ostralegus

Family — Charadriidae—

Vehellus leucurus
Vanellus gregarius
Vanellus indicus indicus
Vanellus malabaricus
Pluvialis squatarola
Pluvialis dominica fulva
Charadrius leschenaultii leschenaultii
Charadrius melanops
Charadrius asisaticus asiaticus
Charadrius dubius curonicus
Charadrius dubius jerdoni
Charadrius alexandrinus alexandrinus
Charadrius alexandrinus seebohmi
Charadrius monogolus atrifrons
Numenius phaeopus phaeopus
Numenius arquata arquata
Numenius arquata orientalis
Limosa limosa limosa
Limosa lapponica lapponica

Tringa erythropus
Tringa totanus totanus
Tringa totanus eurhinus
Tringa stagnatilis
Tringa nebularia
Tringa ochropus
Tringa glareola
Tringa terek
Tringa hypoleucos hypoleucos
Arenaria interpres interpres
Limnodromus semipalmatus
Capella solitaria solitaria
Capella nemoricola
Capella stenura
Capella megala
Capella media
Capella gallinago gallinago
Capella minima
Scolopax rusticola rusticola
Colidris tenuirostris
Calidris albus
Calidris minutus
Calidris temminchii
Calidris subminutus
Calidris acuminatus
Calidris testaceus
Limicola falcinellus falcinellus
Limicola falcinellus sibirica
Philomachus pugna
Phalaropus lobatus

Family—Rostratulidae—

Rostratula benghalensis benghalensis

Family—Recurvirostridae—

Himantopus himantopus himantopus
Recurvirostra avosetta

Family—Dromadidae—

Dromas ardeola

Family—Burhinidae—

Burhinus oedicnemus indicus
Esacus magnirostris recurvirostris

Family—Glareolidae—

Cursorius coromandelicus
Cursorius bitorquatus
Glareola pratincola pratincola
Glareola pratincola maldivarum

Family—Stercorariidae—

Catharacta skua antarctica
Catharacta skua lennbergi
Stercorarius Pomarinus

Family—Laridae—

Larus argentatus heuglini
Larus argentatus mongolicus
Larus fuscus fuscus
Larus icthyaetus
Larus brunnicephalus
Larus ridibundus ridibundus
Chlidonias hybrida indica
Chlidonias leucoptera
Gelochelidon nilotica nilotica
Hydroprogne caspia caspia
Sterna hirundo hirundo
Sterna hirundo tibetana
Sterna dougallii Kerustes
Sterna repressa
Sterna sumatrana sumatrana
Sterna acuticauda
Sterna anaethetus anaethetus
Sterna anaethetus antarctica
Sterna fuscata nubilosa
Sterna albifrons albifrons
Sterna albifrons saundersi
Sterna albifrons pusilla
Sterna bergi velox
Sterna bengalensis bengalensis
Anous stolidus pileatus
Anous tenuirostris worcesteri
Gygis alba monte
Rhynohops albicollis

Order—Strigiformes.

Family—Strigidae—

Bubo zeylonensis leschenault
Bubo zeylonensis zeylonensis
Strix leptogrammica indranee

Order—Coraciiformes.

Family—Alcedinidae—

Ceryle rudis leucomelanura
Ceryle rudis travancoreensis
Alcedo atthis taprobana
Alcedo meningting coltaorti
Alcedo meningting phillipsi
Ceyx erithacus erithacus
Pelargopsis capensis capensis
Halcyon coromanda coromanda
Halcyon smyrnensis fusca
Halcyon pileata

Order—Passeriformes.

Family—Corvidae—

Corvus splendens splendens
Corvus splendens protegatus
Corvus macrorhynchos levaillanti
Corvus macrorhynchos culminatus.

OCCURRENCE OF THE ISOPOD FISH PARASITE, CYMOTHOA INDICA IN THE ADYAR FISH FARM, MADRAS.

BY

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Introduction.

The Model Estuarine Fish Farm at Adyar consists of a lagoon which joins the Adyar river on its northern bank, close to its mouth, across which a regulator has been constructed. The reservoir so formed supplies water to a series of nurseries, breeding ponds, rearing ponds and marketing ponds. The whole farm covers an area of 55·4 acres. Several species of fish such as *Chanos chanos*, *Megalops cyprinoides*, *Tilapia mossambica* *Etroplus suratensis*, *Elops indicus* and Prawns such as *Penaeus indicus* and *Penaeus carinatus* have been stocked in the rearing ponds and observations made on their growth, breeding and other habits.

Tilapia mossambica, the recently imported African Cichlid fish which breeds and multiplies rapidly and grows to a fairly large size in fresh water was introduced in some of the rearing ponds on 30th December 1959. One hundred and twenty five Tilapia along with 500 Megalops cyprinoides were stocked in an area of one-sixth acre.

Observations on Parasite on Tilapia.

In August 1960, *Cymothoa indica*, an *Isopod parasite* recorded by Panikkar and Aiyar (1937) on the Cichlids (*Etroplus maculatus* and *Etroplus suratensis*), the Gobids (*Glossogobius guiris* and *Acentrogobius viridipunctatus*) and the cat fish (*Macrones sp*) in the Adyar backwaters, was commonly found infesting the mouth cavity of *Tilapia mossambica* but not infesting *Megalops cyprinoides* which was in the same tank. The parasites were found singly or in pairs and when found in pairs consisted of a large female and a small male.

The following table shows the percentage of *Tilapia* infested with the parasites in various months.

Month.	*Date of observation.*	*Percentage of fish infested.*
1960—		
August ..	*20th August 1960* ..	22
September ..	24th September 1960 ..	38
October ..	27th October 1960 ..	32
November ..	30th November 1960 ..	18
December ..	21st December 1960 ..	Nil.
1961—		
January ..	28th January 1961 ..	7
February ..	18th February 1961 ..	2
March ..	18th March 1961 ..	3
April ..	26th April 1961 ..	Nil.
May ..	31st May 1961	6
June ..	28th June 1961	Nil
July ..	22nd July 1961	Nil
August ..	24th August 1961 ..	33

The Hydrological conditions in the various months are as follows:—

Month. (1)	*Water temperature. °C.* (2)	*Specific gravity.* (3)	*Turbidity. cm.* (4)	*Salinity per cent.* (5)	*Oxygen cc/l.* (6)	*Carbon dioxide p.p.m.* (7)	*Silicates Mg/l.* (8)	*P.H.* (9)	*Depth feet inches.* (10)
1960—									
August	29·5	1·020	46·0	36·2	4·34	Nil.	64·9	8·4	5 10
September	28·0	1·021	60·00	28·5	4·60	2·0	41·6	8·4	6 6
October	28·0	1·020	65·75	26·20	4·27	Nil.	21·5	8·2	5 6
November	26·0	1·010	97·75	6·6	4·75	Nil.	19·0	8·2	6 0
December	26·0	1·010	81·25	16·25	4·34	1·0	13·0	8·2	4 9
1961—									
January	25·9	1·010	84·5	23·14	3·98	1·0	11·0	7·8	4 3
February	27·5	1·012	94·0	25·31	4·06	1·0	21·5	8·0	4 2
March	28·0	1·012	100·5	30·94	6·09	Nil.	28·975	8·2	4 0
April	29·0	1·020	93·5	35·53	3·90	Nil.	46·6	8·4	4 0
May	30·0	1·020	112·5	32·10	2·43	Nil.	28·83	8·0	4 2
June	29·0	1·016	103·0	32·9	4·00	Nil.	28·10	8·0	4 10½
July	28·0	1·018	108·0	30·25	4·11	Nil.	18·50	8·2	5 3
August	29·0	1·014	78·5	28·62	3·85	2·5	8·0	8·3	4 11

The Hydrological conditions such as water temperature, specific gravity, turbidity, salinity, silicates, pH and depth are at their highest in the months of August, September and October. It is during these months that young *Cymothoa* are found in the plankton at the rate of one to three per cubic centimetre. Brood pouches of adults are found with fully developed larvae, larvae partly shed or larvae completely shed, indicating the beginnings of the free-living life of the parasite. In November, when the monsoon is in full sway, salinity is at its lowest. Depth of water is high but Specific gravity, Turbidity, Silicates and PH are all decreasing. The percentage of fish attacked also decreases. This may be due to the death of the adults after shedding of the larvae, induced by changing hydrological conditions. The Hydrological conditions continue to be low in December and January. Young parasites are in search of hosts and fresh infection is found to take place at this time. Old parasites disappear almost completely. From February onwards, hydrological readings show a gradual rise. Young Cymothoans, females of which have developing brood pouches are a common feature of fish that have been attacked. By March, Cymothoans with eggs in brood sac are available and in the following months various stages of the embryos can also be seen in the brood sacs. The very large drop in the percentage attacked from December onwards is partly due to the removal of parasites from the fish whenever they were available.

Details of *Cymothoa indica* examined from *Tilapia mossambica* from the rearing ponds and from the reservoir are as follows:—

Serial number.	*Length of Tilapia in mm.*	*Sex.*	*Gonadial condition (stage).*	*Weight of Tilapia in grms.*	*Length of parasite in mm. Female.*	*Breadth of parasite in mm. Female.*	*Length of parasite in mm. Male.*	*Breadth of parasite in mm. Male.*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Date—20th August 1960.					
1	141	F	IV	55	22	..	..	..	*Brood sac empty. Flesh grown around claws.*
2	147	F	IV	85	15	..	6	..	Brood sac developing.
3	145	F	IV	70	17	..	..	..	Brood sac with larvae.
4	170	M	I	110	22	..	..	..	Brood sac empty.
5	147	F	V	80	16	..	8	..	Brood sac with larvae. Flesh grown around claws in male and female.
6	140	F	IV	80	16	..	6	..	Brood sac developing.
7	148	F	IV	85	20	..	..	..	Brood sac with larvae.
8	110	F	IV	47	16	..	8	..	Brood sac empty
9	118	F	IV	55	20	..	..	..	Brood sac with larvae. *Tilapia* had bred. Those with and without parasites had gonads in advanced stages of development.
				Date—24th September 1960.					
10	150	F	II	95	17	..	..	..	..
11	149	M	I	90	19	..	..	..	..
12	150	M	I	130	17	..	..	..	..
13	155	F	V	100	17	9	..	..	Flesh around claws.
14	146	F	V	80	19	..	6	..	..
				Date—27th October 1960.					
15	160	F	IV	75	19	..	..	..	..
16	176	M	IV	95	21	..	..	..	..
17	175	F	IV	110	19	..	..	..	..
18	165	F	IV	75	17	..	..	..	..
19	158	F	IV	65	16	..	9	..	Brood sac empty.
20	160	F	IV	75	..	..	12	..	..
21	155	F	IV	60	18	..	13	..	Brood sac empty
22	138	F	III	40	20	..	10	..	Brood sac empty.
				Date—30th November 1960.					
23	140	F	..	45	16	..	12	..	..
24	167	F	..	75	16	..	..	..	..
25	162	F	..	65	18	..	..	..	..
26	155	F	..	65	..	..	14	..	..
				Date—28th January 1961.					
27	145	F	..	80	21	..	9	..	..
28	163	F	..	75	19	..	9	..	..

Serial number.	*Length of Tilapia in mm.*	*Sex.*	*Gonadial condition in mm. of stage.*	*Weight of Tilapia in grams.*	*Length of parasite in mm. (Female.)*	*Breadth of parasite in mm. (Female.)*	*Length of parasite in mm. (Male.)*	*Breadth of parasite in mm. (Male.)*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Date—18th February 1961.					
29	136	M	..	65	22	..	10	..	....
				Date—18th March 1961.					
30	155	F	..	85	18	..	..	..	....
				Date—31st May 1961.					
31	147	M	..	30	22	..	..	..	....
				Date—24th August 1961.					
32	122	M	..	50	16	..	3	..	429 developing embryos in early stage—Tongue reddish.
33	107	F	..	52	14	..	..	..	Bleeding during removal of parasite.
34	145	M	..	30	20	..	8	..	....
				Date—3rd January 1962.					
35	150	F	..	..	..	..	5	2	From 3rd January 1962 onwards. Tilapia examined are from reservoir.
				Date—6th February 1962.					
36	149	M	..	..	4	1·5	8	3	....
37	145	M	..	..	14	7	5	2	....
							6	2·5	Three males in one.
							3	1	....
38	139	M	..	..	..	..	5	2	....
39	133	M	..	..	..	..	5	2·5	....
40	140	M	..	..	12	5	6	2	Two males in one.
							4	1·5	....
41	105	F	..	..	9	3	..	..	....
42	124	F	..	..	..	..	5	2	Two males in one.
							5	1·5	
				Date—8th February 1962.					
43	143	M	..	..	11	4	5	3	*Zoothamnium* found on Cymothoans.
44	135	M	..	..	..	..	5	3	....
45	149	M	..	..	..	..	5	2·5	....
46	149	M	..	..	11	4	5	2	One male found on gills, 2 males and 2 females in one.
					5	2·5	4	1·5	
47	139	F	..	..	9	4	6	3	....
48	147	M	..	..	..	..	7	2·5	....
49	124	F	..	..	12	6	5	2	Eggs in brood sac.
50	137	M	..	..	7	3	6	2·5	Two males.
							5	1·5	
51	126	M	..	..	12	5	4	1·5	Two females.
					4	2			
52	145	M	..	..	9	4	..	..	....
53	123	M	..	..	11	5	..	..	....
54	124	F	..	..	5	2	5	1·5	Male found outside behind eye.
				Date—20th February 1955.					
55	150	M	..	..	15	5	5	1·5	Hairs on Uropod lost in male.
56	150	M	..	..	7	3	3	1·0	Male has characters of larva and adult.
					6	3			
57	153	M	..	..	11	5·5	7	3·5	....
58	155	M	..	..	7	3	4·5	2	....
59	157	M	..	..	..	..	2	1	Has characters of both larva and adult of.

The marketing ponds of the farm and the reservoir contain several species of fish the main varieties being *Mugil sp. Chaetossus nasus*, *Leiognathus sp.*, *Gerres sp.*, *Caranx sp.*, *Serranus sp.*, *Engraulis sp.*, *Stolephorus sp.*, *Sillago sihama*, *Therapon sp.*, *Scatophagus sp.*, *Teuthis java* and *Hemirhampus sp.* But *Cymothoa indica* was found on *Etroplus suratensis*, *Macrones gulio*, *Gobius giuris*, *Polynemus tetradactylus*, *Pomodasys hasta* and *Sphyraena obtusata*, but not on the other species. Next to *Tilapia mossambica*, infection was heavy on *Macrones gulio*. Infection of *Etroplus suratensis* and *Gobius giuris* ranked third in the order. The three other species were rarely available and it was interesting to note that some of the others obtained were also infected.

Particulars of parasitic infection on the other species of fish are given below :—

I. Macrones gulio.

Serial number.	*Length of Macrones in mm.*	*Length of parasite in mm. (Female.)*	*Breadth of parasite in mm. (Female.)*	*Length of parasite in mm. (Male.)*	*Breadth of parasite in mm. (Male.)*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Date—6th February 1960.			
1	57	..	..	..	..	With parasite.
			Date—6th December 1960.			
2	83	..	..	4·5	..	....
			Date—18th February 1961.			
3	93	..	..	10·0	..	....
4	118	22	..	..	..	....
5	110	18	..	..	..	....
			Date—24th August 1961.			
6	126	15	..	7	..	355 eggs in brood sac.
			Date—25th August 1961.			
7	93	11	..	6	..	....
8	113	12	..	2	..	....
9	91	10	..	6	..	....
10	83	10	..	4·5	..	....
			Date—26th August 1961.			
11	113	13	..	8	..	....
			Date—28th August 1961.			
12	90	8	..	..	..	....
			Date—29th August 1961.			
13	114	..	..	9	..	14 per cent covered with *Zoothamnium*.
14	113	..	..	5	..	Eyes very clear.
15	118	..	..	9	..	Partly covered with *Zoothamnium*.
16	110	14	..	7	..	....
17	94	9	..	..	..	*Zoothamnium*, light green and feathery.
18	101	13	..	8	..	Both partly covered with *Zoothamnium*.
19	90	7	..	..	..	....
20	79	5	..	..	..	With *Zoothamnium*.
			Date—30th August 1961.			
21	80	..	..	8	..	....
			Date—31st August 1961.			
22	136	..	..	5	..	....
23	117	17	..	4	..	....
24	83	7	..	..	..	....
			Date—4th September 1961.			
25	151	..	..	..	..	With parasite.
26	118	..	..	..	..	Do.
27	106	..	..	..	..	Do.
28	108	..	..	..	..	Do.
29	88	..	..	..	..	Do.

Serial number.	*Length of Macrones in mm.*	*Length of pardsite in mm. (Female.)*	*Breadth of parasite in mm. (Female.)*	*Length of parasite in mm. (Male.)*	*Breadth of parasite in mm. (Male.)*	*Remarks.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Date—6th September 1961.			
30	117	14	..	9	..	Brood pouch with larvae. Some already shed.
			Date—9th October 1961.			
31	152	9			..	With *Zoothamnium.*
32	140	7			..	Do.
33	135	15		9	..	....
			Date—21st October 1961.			
34	135	16	..	9	..	With *Zoothamnium,*
35	88	11	..	4·5	..	Do.
			Date—27th October 1961.			
36	135	18	..	{ 9 4 8 }	..	One male on right side of mouth. Another on left. Third on gills. Larvae in brood pouch.
			Date—31st October 1961.			
37	153	14	9	7	3	....
38	114	9	4	5	2	....
39	118	12	6	7	3	....
40	114	..	..	2	1	Male found behind gill slit.
			Date—4th November 1961.			
41	129	16	9	7	4	Eggs in brood sac.
42	110	..	..	6	3	....
			Date—8th December 1961.			
43	156	17	9	..	..	*Eggs in brood sac.*
44	137	17	9	8	3	344 eggs in brood sac.
45	138	15	8	8	4	With *Zoothamnium.* Larvae in brood pouch.
46	129	10	4	..	..	Brood pouch very small.
47	111	14	7	7	3	....
			Date—14th December 1961.			
48	135	15	8	8	3	Eggs in brood pouch. Whitish growth of *Zoothamnium.*
			Date—3rd January 1962.			
49	190	12	6	7	3	....
50	97	11	5	5	2	With *Zoothamnium.*
			Date—8th February 1962.			
51	148	6	3	5	2	Female on gill cover.
52	168	10	5	..	..	Found on gills.
			Date—16th February 1962.			
53	100	8	4	..	..	....
54	95	10	6	..	..	....
55	83	10	6	..	..	With eggs.
			Date—16th February 1962.			
56	77	10	4	..	..	....
57	91	11	6	..	..	With eggs
58	72	9	5	5	3	Male on gills.

Serial number.	*Length of Gobius in mm.*	*Length of parasite in mm. (Female.)*	*Breadth of parasite in mm. (Female.)*	*Length of parasite in mm. (Male.)*	*Breadth of parasite in mm. (Male.)*	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			II. Gobius giuris.			
			Date—6th February 1960.			
1	96	..	..	..	..	With parasite.
2	73	..	..	..	..	Do.
			Date—11th August 1960.			
3	256	..	..	..	..	With parasite.
			Date—21st April 1960.			
4	250	..	..	..	..	With parasite.
			Date—25th August 1960.			
5	113	11	..	6	..	....
			Date—31st August 1961.			
6	190	20	..	10	..	....
7	111	..	..	6	..	....
			Date—31st October 1961.			
8	173	20	11	9	4	Second male on gill cover.
				8	..	
9	146	13	6	6	2·5	
10	131	14	6	7	2·5	....
			Date—3rd November 1961.			
11	210	20	..	11	4	Completely covered with black scum of *Zoothamnium*. Young in brood sac.
12	162	18	8	9	4	....
13	152	14	6	..	..	....
14	144	15	5	7	3	....
			Date—16th February 1962.			
15	120	15	5	8	3	Male parasite seen for the first time facing inwards.
			Date—17th February 1962.			
16	150	..	..	..	..	Three parasites. One female with eggs. Two males.
			Date—1st March 1962.			
17	119	15	7	8	4	Eggs in brood sac. *Zoothamnium* on both. Male completely covered.
			Date—2nd March 1962.			
18	126	12	5	6	3	Eggs in brood sac.
19	70	5	3	..	..	....
			III. Etroplus suratensis.			
			Date—6th December 1960.			
1	32	..	..	..	..	With parasite.
2	33	4·5	..	4·0	..	....
3	32	..	..	..	..	With parasite.
4	33	..	..	..	..	Do.
5	32	..	..	..	..	Do.
6	34	..	..	..	..	Do.

Serial number.	*Length of Etroplus in mm.*	*Length of parasite in mm.*	*Breadth of parasite in mm.*	*Length of parasite in mm.*	*Breadth of parasite in mm.*	*Remarks.*
		Female.	*Female.*	*Male.*	*Male.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Date—24th August 1961.			
7	118	16	..	8	..	....
8	74	8	..	5	..	....
			Date—25th August 1961.			
9	79	12	..	5	..	...
			Date—28th August 1961.			
10	63	10	..	..	..	Covered with *Zoothamnium*.
			Date—26th October 1961.			
11	97	14	..	8	...	Larvae in brood sac.
			IV. Polynemus tetradactylus.			
			Date—22nd March 1960.			
1	230	..	..	..	..	With parasite.
			Date—28th April 1960.			
2	250	..	..	..	..	With parasite.
			Date—28th June 1960.			
3	289	..	..	..	..	With parasite.
			V. Pomodasys hasta.			
			Date—18th February 1961.			
1	212	..	..	..	..	With parasite.
			VI. Sphyraena obtusata.			
			Date—1st March 1962.			
1	136	9	3·5	2	1	....

Cymothoa indica is usually found singly or in pairs but sometimes there are three or four individuals on the same fish. When it is a single individual, the parasite is either a male or female more commonly a female. When in pairs, there is usually a large female attached to the tongue of the fish, while the smaller male fixes itself just behind or right at the back of the mouth towards one side. If one more male is present, it occupies the hind corner of the mouth on the opposite side. Sometimes a third male may be found on the gill-rakers, or gill covers or even on the head somewhere behind the eye. Both the male and female occupying the mouth, usually face the mouth opening. It was only on one occasion that a male parasite was found facing the gullet of the fish. Two females are sometimes found on the same fish, when the larger takes a central position.

The largest female parasite recorded is one of length 22 mm. The greatest width recorded is 11 mm. The length is usually more than double the width. The largest male recorded is 14 mm. long. The greatest width recorded is 4 mm. The male, at its largest is usually, just a little more than half the length of the female. It is commonly half the length of the female or smaller. The width of the male is half or less than half its own length.

The general body form of the adult female is obovate and reminds one of an inverted turnip with the fan like telson and uropods representing the leaves. The male body form is oval. The head and thorax together form the Cephalothorax. The head is about as long as it is broad and is partly sunk in the first segment of the thorax. It is narrow anteriorly and broadest posteriorly. The eyes are paired, sessile, large, compound, darkly pigmented and they extended downwards on either side of the head. They become less prominent with age. The appendages of the head consist of two pairs of antennae. The first pair consists of eight stout and large segments. It extends to the posterior margin of the head. The basal segments of the two are widely separated. The second pair of antennae consist of nine narrower and smaller segments each and also extend to the posterior margin. The basal segments are even more widely separated than the first. At the tip of the distal segment of each second antenna there are two very fine setae.

The mouth parts are specially modified for their parasitic mode of life and are best suited for piercing and sucking. There are a pair of maxillipeds, a pair of first maxilla, a pair of second maxilla and a pair of mandibles with three segmented palp.

The thorax is seven segmented. The first thoracic segment is longer than the second but not as wide. Its antero-lateral angles are acute and produced forwards to half the length of the head. The thoracic segments gradually widen out until it is widest at the fifth thoracic segment. After this the segments that follow are narrower. The length of the thoracic segments after the second gradually increase until it is longest at the fourth segment. The segments following this become shorter by stages. There are seven pairs of clawed thoracic appendages which are well adapted for their prehensile function. The first three pairs are short and of these the first is the shortest and the third the longest. The claws of these three pairs curve backwards. The remaining four pairs of thoracic appendages are longer than the first three and have the claws curved forwards in opposition to those of the first three pairs. All seven pairs of thoracic appendages are six segmented.

The abdomen is clearly differentiated from the thorax in that its segments are abruptly narrower and shorter than the thorax. It consists of six segments, the sixth segment being the broad fan-like telson which is slightly notched in the middle of its posterior margin. The abdominal appendages consist of 5 pairs of biramous pleopods which are broad, rounded and fan-like, a pair to each of the first five segments. The last segment, the telson, carries a pair of two-jointed, biramous Uropods, which are slightly shorter than the telson. The lamellar pleopods are both natatory and respiratory in function. The telson with uropods also helps in swimming. In males, the second pair of pleopods shows a modification of the Endopodite known as *Appendix masculina*. In females, *Marsupial plates*, eight in number are developed to form an incubatory pouch, on the ventral side of the thorax, extending between the thoracic appendages. The arrangement of these plates is very interesting. The posterior-most plate overlaps the hind ends of the foregoing pair of plates. The anterior-most plate is overlapped by the next pair of plates. The three central pairs of plates are overlapped at their posterior ends by the plate following and overlap anteriorly the foregoing plate. These plates are transparent and membranous. They are so closely packed in the early stages that it forms a tight compartment. As the eggs form within the brood pouch it takes a more convex appearance. At the time of shedding of the larvae, the plates are more loosely packed and an opening forms anteriorly between the anterior-most plate and the first pair of plates, by a spreading out of the plates to give more space.

In very early stages of the development of eggs in the brood pouch there are masses of yolk but with the outer membrane not yet formed. When the eggs are differentiated they are rounded with a large yellow yolk. They give the brood sac a lemon yellow colour as the plates are transparent. As development proceeds the egg lengthens out being broader towards the anterior end. The number of eggs or embryos in a brood sac varies as shown below :—

Length of parasite mm.	*Breadth of parasite mm.*	*Number of eggs or larvae.*	*Remarks.*
12	7	143	Eggs partly formed Rest as yolk pieces
15	7	629	Eggs.
15	9	443	Eggs.
15	..	355	Eggs.
16	..	429	Developing embryo
17	9	344	Eggs.
19	10	450	Larvae.
19	11	498	Larvae.

The eggs start forming when the parasite is about 10–12 mm. in length. The larvæ resemble the adult in their body consisting of a head, thorax and an abdomen with similar appendages on each segment. The difference lies in the fact that the appendages have their segments lengthened out so that the antennae, thoracic appendages, pleopods and uropods are all long and spread outwards. The eyes are large, well developed and clearly compound. In the early larval stages, hairs are absent on the appendages but in the later stages, the flattened pleopods, telson and uropods develop hairs which probably help in swimming in the free living pelagic life. Similarly fine, spiny processes develop in the various segments of the thoracic appendages especially the claws. This is probably to help in prehension when they chance to land upon a host during their pelagic life. The colour of the brood pouch changes from lemon yellow to dirty brown with the absorption of yolk and the formation of the larvæ. The colour of the larvæ is dirty brown giving the same colour to the pouch. The larvæ measure from 1 to 2 mm. in length and 0·5 mm. in width at this stage, the transitory stage, when the larvae leave the brood pouch, for their short free living life, before their parasitic life. They are very efficient and fast swimmers at this stage.

As the time for a parasitic life approaches the limbs shorten. The dorsal carpace slowly begins to harden and takes an arched appearance. The thoracic appendages which are spread out curve inwards so that when viewed dorsally they are first partly hidden and then completely drawn in. The pleopods which were linear become fan-like or lamellate, now more useful for respiration than for swimming, although they are still utilised for swimming also. The earliest stage at which they secure a host is at a length of 2 mm. and a width of 1 mm. The increase in breadth during this period is slow. Parasites 4 mm. long and 1·5 mm. broad still show larval characters. Hairs on uropods and pleopods remain and if they are put into water they swim well. The uropods are still longer than the telson. Stouter spines are found on the thoracic appendages, which have still to bend inwards completely.

When the parasite is 5 mm long and 1·5 mm. broad and has settled down to a parasitic mode of life, it loses the hair on its pleopods, uropods and telson as they are no longer required. Thoracic appendages are completely drawn in. The stout spines become blunt projections. Powers of swimming are still present, though to a small

degree. The male and female resemble each other but can be differentiated by their variation in shape. Their colour is dirty-white but they sometimes *take on a blackish* or a brownish tinge. Both the male and the female rest with their claws well embedded in the soft epithelium of the fishes' mouth. The telson is always tilted upwards to give enough. moving space for the pleopods below which are constantly vibrating, as a part of their function as respiratory organs. Both the male and the female produce enough irritation with their prehensile claws in the mouth epithelium of the fish so as to cause it to grow up around the tips of the claws themselves, when infestation has been for a long period. The parasite has to be plucked out to be removed, when there is bleeding and bits of flesh are found sticking to the claws. The place of attachment is found to be red and sore, the degree of injury being greater with a longer period of infestation. *The parasite also loses its convex dorsal form with long* infestation and becomes softer and flatter. The clear compound eyes of early parasitism gradually degenerate until there is only a faint reminescence of its former presence.

The early stages of parasitism are however temporary. Several parasites seem to get into the same fish but they do not seem to remain there for long. At the earliest opportunity they have to move out for a more suitable host. This is clearly understood from the fact that where several parasites are found they are usually young. It is more common to find the older ones either singly or in pairs. They are single probably when a male has still to find its way in. That the young parasites do move out when conditions are unfavourable is proved by observation. When a fish dies the very old parasites remain within and die with the fish whereas the young ones which are still capable of walking and swimming, creep out and get into the water. If a live fish is introduced into the water they immediately get on to it and try to get into the buccal cavity of the fish through the mouth. The fish resents the presence of the intruder and tries to get rid of the parasite as it climbs up, by vigorously shaking its head and swimming fast, but to no effect as the claws of the parasite take a firm grip of the fish.

Whether the parasite always gets into the buccal cavity through the mouth is not certain. In *Etroplus suratensis* the mouth is very small but we find large parasites within the buccal cavity which can be removed only by cutting open the sides of the mouth The parasites can easily get in through the mouth during the free living stage when they are 1 mm. to 2 mm. in length but it is possible that they get in through the gill slits as individuals have been found on the gill rakers. Even in this case only very young parasites were found on the gills, as infection is usually during the early stage. When they try to get out after temporary infection they try to do so through the mouth opening which is nearest, but this is not possible in later stages, in the case of *Etroplus suratensis* which has a very small mouth.

Though the fish shows a dislike to the entry of the parasite, its presence does not seem to affect the fish seriously. *Its presence in the mouth* may prevent free entry of water and food. The injury caused by the penetrating claws of the parasite may cause discomfort. But the fish seems to get used to this in course of time.

That the body fluids are sucked up by the parasite is quite clear but large quantities of it could not possibly be taken in, as the parasite does not shift its position over a wide area. The body fluids lost do not seem to seriously affect its growth The gonads are unaffected. Advanced stages of gonads are found in both parasitised fish and unaffected fish in the breeding period. Mechanical removal of the parasites from the fish affected, help to lessen the intensity of attachment. The fish are able to withstand the process of parasitic removal and there is cent per cent survival of the fish after this.

A common and interesting feature was to find both male and female parasites from a size of 4·5 mm. and over to be partly or wholly covered dorsally with a greenish, blackish or dirty white coating or scum, or with a light green, feathery, plant like growth. Microscopic examination revealed them to be colonies of the vorticellid, *Zoothamnium*. Jones and Job (1938) have noted an interesting case of animal association between brackish water fish *Accentrogobius neilli* and *Zoothamnium*, it being attached *to the teeth of fish. In this case, suitable substratum for* attachment is provided by the hard carapace of *Cymothoa indica*. Probably remnants of the fishes food serve as food of the *Zoothamnium*. This is a case of Commensalism with continuous contact, where the individual derives both food and shelter.

Discussion.

Cymothoa indica is a typical parasite in that it lives in close contact with its host drawing nourishment from it but without causing its death. The parasite shows a preference for the fishes it selects. Young larvae of *Cymothoa indica* are set free from the brood pouches mainly in the months of August, September, October and November. In six months time, i.e., in March, April and May, these young parasites are mature with eggs *completely* formed in the brood pouch. Development of the eggs into larvae in the brood sac stretches over another six months. From August onwards eggs are again noticed in brood pouches which suggests two breeding periods during the year. The life span of an individual does not appear to be less than a year. But in the estuary and reservoir, where fish rarely survive over a year, as in summer, water level is very low and most of the fish are caught, the parasites do not get a chance of living to their maximum span of life.

Acknowledgment.

Thanks are due to Sri A. J. Thangadurai, Laboratory Assistant, for giving the hydrological data of the pond under study.

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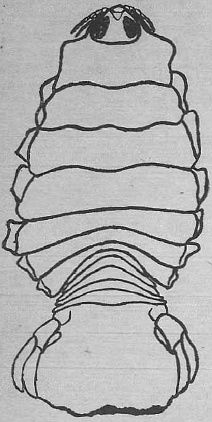

FIG. 1—Adult Female (Dorsal view).

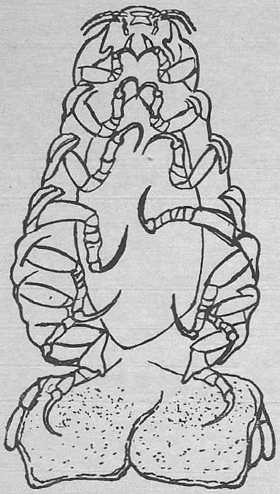

FIG. 2—Adult Female (Ventral view).

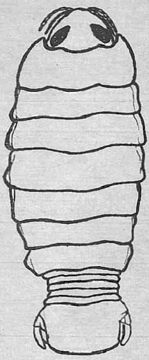

FIG. 3—Adult Male.

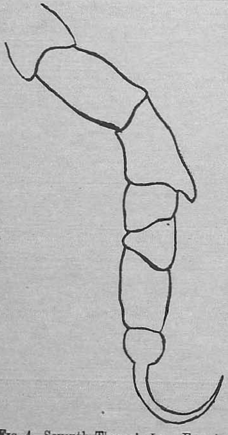

FIG. 4—Seventh Thoracic Leg (Female.)

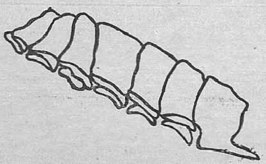

FIG. 5—Lateral view of Thorax of Adult Female.

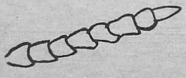

FIG. 6—First Antenna.

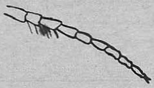

Fig. 7—Second Antenna.

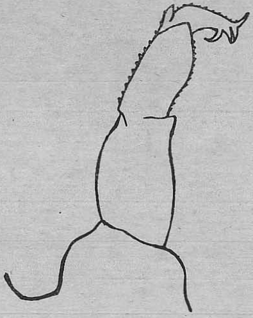

Fig. 8—Maxilliped.

Fig. 9—First Maxilla.

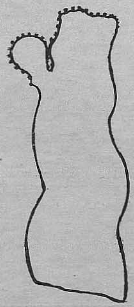

Fig. 10—Second Maxilla.

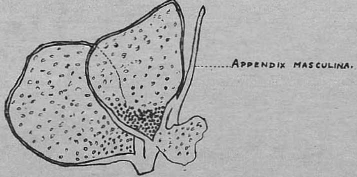

Fig. 11—Male Pleopod (Second).

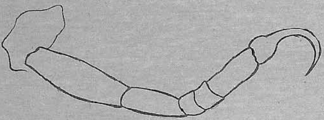

Fig. 12—Third Thoracic leg.

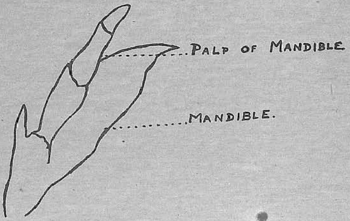

Fig. 13. Mandible with palp.

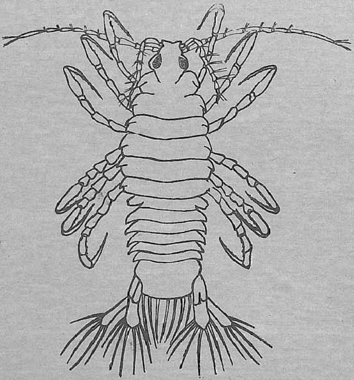

Fig. 14—Young of *Cymothoa indica* just before it leaves the broodpouch.

AN UNUSUAL DRIFTING OF GLAUCUS MARINUS (Du Pont) FROM THE BAY OF BENGAL INTO THE ENNORE RIVER NEAR MADRAS.

BY

P. I. CHACKO AND A. RAJAGOPAL, MARINE BIOLOGICAL STATION, ENNORE.

Glaucus marinus (Mollusca, Gastropoda, Euthyneura, Opisthobranchiata, Nudibranchiata, Aeolidiidae), is a pelagic sea-slug occurring in the Bay of Bengal. It is about 30 to 50 millimetres in length; and is beautifully coloured with blue and purple tinges over a white background. It floats on its back in the sea with its blue ventral side upwards, thus correlating with light and shade of the marine environment. This habit enables it to get drifted with the currents and come into contact with other small soft-bodied pelagic animals to which it adheres. In this process its appendages and radula play an important part.

Though this sea-slug is thrown up along the Madras beach occasionally, an unusual instance of drifting of very large numbers of this animal into the Ennore river occurred in the month of December 1960. Cyclonic weather conditions prevailed from 24th to 27th day of the month. Several living and dead specimens of the Siphonophore, *Porpita pacifica* Lesson were washed ashore on the beach and also drifted into the Ennore river. But during the later hours of the 28th, there was an unusual drift from the sea towards the shore, and this threw a large numbers of *Glaucus marinus* into the river. On the 29th morning, the southern bank of the river estuary was found strewn with these dead sea-slugs in the form of a belt about one kilometre in length and one metre in width. On an average 200 individuals were counted in one square metre of the area.

It is likely that the depression and the consequent whirling that prevailed in the Bay of Bengal at that time would have caused an aggregation of these pelagic nudibranchs into a mass, which would have been brought towards the shore near Ennore by the north-east monsoonic drift and then cast into the river by the high tide. The less saline water (17·32 parts per thousand) of the river estuary would not have been conducive to the survival of the organisms. The temperature of the river water ranged from 25·0 to 25·5 °C during that period. The atmospheric temperature was 25·5–27·0°C, humidity 90–93 per cent, specific gravity of water 1·012–1·016 and pH 8·4. An instance of this nature has not been recorded before. However, this is a typical example indicating as to how weather and oceanographic conditions affect the life of marine organisms.

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SWARMING OF THE CTENOPHORE, PLEUROBRACHIA GLOBOSA, MOSER IN THE ENNORE RIVER ESTUARY NEAR MADRAS.

BY

P.I. CHACKO and A. RAJAGOPAL, MARINE BIOLOGICAL STATION, ENNORE.

The Comb-jelly, *Pleurobrachia globosa*, Moser (Phylum *Ctenophora*, Class *Tentaculata*, Order *Cydippida*) occurs in the Indian Ocean. It has been recorded by several workers from plankton collections made from the inshore waters of the Indian coast. Occasionally it gets drifted into estuaries and also gets washed along the beach. In the Ennore river estuary near Madras this Ctenophore is rarely met in the plankton collections. But an unprecedented swarming of this organism occurred here in the month of March 1961.

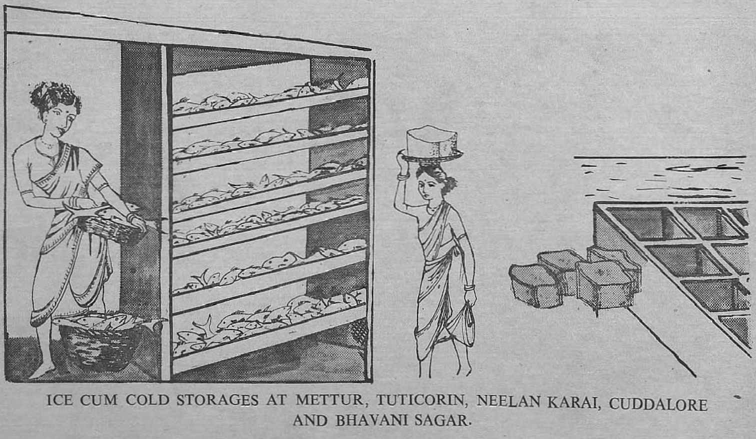
In the plankton collected from the estuary in the early hours of 4 a.m. on 21st March 1961, there was not even a single specimen of *Pleurobrachia globosa*. But when plankton was collected six hours later, that is, at 10 a.m., over 500 specimens of this Ctenophore were obtained in a tow-net haul of 10 minutes duration. The net was clogged and could be lifted only with difficulty. The other planktonic organisms in the collection were negligible and consisted of few diatoms (*Chaetoceros*, *Coscinodiscus* and *Biddulphia*), dinoflagellate (*Ceratium*), Cystoflagellate (*Noctiluca*), Copepods, nauplius larvae and Zoea Larvae. Eight hours still later (4 p.m.) it was seen that the southern bank of the river was strewn with these Ctenophores in a thick mass to a length of about one kilometre. It was estimated that there were about 600 dead individuals per square metre on the average.

The sea was very rough on 20th and 21st of March 1961 and there was a large inflow of sea water into the estuary during high tide. It is evident that these Ctenophores got congregated in the ocean and were then drifted towards the coast and pushed into the river by the ocean currents and tide during the morning hours of 21st of March 1961.

The meteorological and hydrographical conditions of the estuary during the period, were as follows :—

Atmospheric temperature ..	28·5 °C. to 32·0°C.
Humidity	94–96 per cent.
Surface temperature of estuary water.	29·0 °C to 30·5°C.
Specific gravity of water ..	1·020 to 1·022
pH of water	8·2.
Salinity of water	28·34 to 28·40 p.p. 1000.
Oxygen content of water ..	2·20 c.c./litre.

These conditions were not suitable to the Ctenophores and therefore they did not survive in the estuary. Such a large scale mortality of this form has not been recorded before in the Madras area. As already explained the weather and oceanographic conditions were responsible for this peculiar incidence.



ICE CUM COLD STORAGES AT METTUR, TUTICORIN, NEELAN KARAI, CUDDALORE AND BHAVANI SAGAR.

PROXIMATE CHEMICAL COMPOSITION OF MARINE FISHES

BY

P. JAYACHANDRAN, FISHERIES TECHNOLOGICAL STATION, TUTICORIN.

Many papers have been published on the nutritive values of the various food fishes both marine and inland Saha and Guha (1939), Basu and De (1938, 1938a), *Niyogi et al* (1941), *Setna et al* (1944), Chari (1948). The present paper gives the results of the study on nutritive value of some of the East Coast Marine Food Fishes as available in Tuticorin Bay.

Methods.

Only the edible portion was taken into consideration for analysis of the nutritive values. Fins, scales. skeletal structures and viscera were removed and the flesh alone was analysed. However, in the case of small fishes, the whole fish was minced and the pulp analysed for proximate composition. The fish for analysis were purchased from the landing place and analysis were carried out on absolutely fresh fish.

A representative sample was obtained by thoroughly mincing about 5 to 10 fishes and mixing them well. Analysis were carried out for the determination of the following constituents, Moisture, Protein, Fat, Ash, $P_2 O_5$, Cao Iron and Copper. The moisture content was determined by drying a weighed sample of the minced pulp to a constant weight in a hot air oven at 100° C. The protein content was calculated by multiplying the total nitrogen, as determined by the Kjedahl distillation method by 6·25, ash by the Stolte's dry ashing method and fat by extracting the dried s ample withether for about 12 to 16 hours in a Soxhlet apparatus. The ash was further analysed for Phosphorus, Calcium, Iron and Copper. The ash was extracted with hydrochloric acid and made up to a known volume. Aliquots were pipetted out for determination of Phosphorus, Calcium, etc. Phosphorus was estimated by the Ammonium-Molybdate volumetric method (Burns—Hunderson 1935) Calcium by Mc. Crudden's Permanganate method, Iron was estmated according to the method of Elvehjam 1930—Kennedy 1927—Colorimetrically and copper using diethyl-dithio Carbonate.

The results of the analysis are given in Table I.

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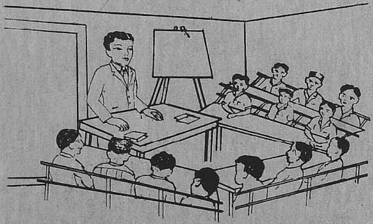
ANALYSIS OF

Serial number and Common English name. (1)	*Scientific name.* (2)	*Average weight.* (3) GM.	*Average length.* (4) CM.	*Edible portion.* (5) PER CENT.
1 Sardine	Sardinella sirm	50	19	71·4
2 Slender shad	Ilisha elongata	453	39	75·0
3 Sprat	Dussumieria acuta	42	11·5	75·0
4 Wolf Herring	Chirocentrus dorab	453	36	60·0
5 Lizard Fish	Saurida tumbil	102	24	66·6
6 Gar Fish	Belone strongylura	50	30	57·0
7 Barracuda	Sphyraena jello	225	60	64·7
8 Cock up	Lates calcarifer	900	46	56·0
9 Coral cod	Serranus miniatus	1,001	36	55·5
10 Reef cod	Serranus undulosus	453	32	62·5
11 Rock cod	Serranus pantherinus	1,021	32	55·5
12 Silver Whiting	Sillago sihama	113	24	75·0
13 Big Jawed Jumper	Lactarius lactarius	128	21	44·4
14 Horse Mackerel	Caranx rottleri	510	25	50·0
15 Malabar horse mackerel	Caranx malabaricus	128	20	66·7
16 Black king fish	Elecate nigra	910	40	75·0
17 Blue Lined snapper	Lutianus rivulatus	1,134	38	45·0
18 Snapper	Lutianus spp.	330	20	45·0
19 Silver belly	Leiognathus splendens	34	12	60·0
20 Dusky surgeon fish	Acanthurus gahm	142	21	60·0
21 Ribbon fish	Trichiurus savala	41	41	88·0
22 Sole	Cynoglossus Semifasciatius	150	31	80·0
23 Seer	Cybium guttatum	353	39·5	70·80

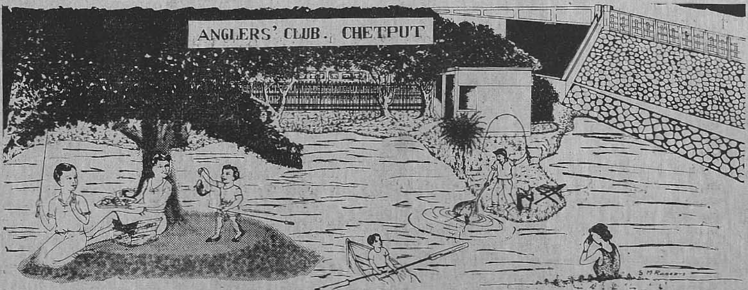


GOVT. FISHERIES TRAINING CENTRES.

MADRAS, TUTICORIN, NAGAPATTINAM AND METTUR.

FRESH FISH.

H_2O (6) PER CENT.	*Protein.* (7) PER CENT.	*Fat.* (8) PER CENT.	*Ash.* (9) PER CENT.	P_2O_5. (10) PER CENT.	*Cao.* (11) PER CENT.	*Iron* (12) *Mg.* PER 100 G.	*Copper* (13) *Mg.* PER 100 G.
77·85	18·2	1·85	0·50	0·03	0·07	8·1	0·36
70·5	19·87	8·2	1·5	0·3	0·28	4·2	0·95
76·3	19·9	4·15	6·7	1·35	1·6	3·7	1·5
78·2	20·7	1·1	1·5	0·20	0·09	4·7	0·25
77·0	19·3	2·5	1·4	0·60	0·35	5·7	3·7
77·4	19·7	1·1	1·6	0·95	0·42	2·4	2·2
81·8	16·2	0·93	1·25	0·39	0·07	4·7	1·5
74·9	14·8	2·8	1·20	0·30	0·32	1·7	0·20
76·7	19·5	5·65	1·35	0·50	0·28	2·5	0·20
80·8	15·8	0·73	1·25	0·60	0·48	2·5	0·20
77·53	17·45	2·0	1·40	0·64	0·275	1·8	0·25
76·3	18·7	0·68	1·37	0·47	0·23	2·2	1·5
70·4	16·0	4·9	1·40	0·50	0·29	2·3	0·20
75·8	18·6	1·3	1·65	0·27	0·28	7·6	4·70
76·0	15·9	1·9	1·82	0·3	0·32	8·2	0·60
75·0	18·7	3·1	1·25	0·60	0·30	3·2	0·50
78·9	16·2	1·1	1·2	0·35	0·11	1·4	·15
78·0	16·1	1·65	1·50	0·23	0·41	1·4	1·40
77·2	16·5	2·9	1·70	0·35	0·45	2·2	1·15
79·0	16·6	0·47	1·20	0·40	0·59	2·4	1·5
75·9	20·7	1·0	2·9	1·28	0·9	0·4	0·3
77·6	19·3	0·51	1·6	0·77	0·35	1·4	1·4
78·7	21·75	3·65	1·2	0·58	0·21	4·7	3·7



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VARIATION IN THE CHEMICAL COMPOSITION OF A FRESHWATER FISH, LABEO FIMBRIATUS

BY

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In migratory marine fishes, variations in chemical composition, especially of fat with season, sexual maturity, etc., have been described (Venkataraman and Chari 1953, Vasavan *et al* 1960, Sohn *et al* 1961) but data on variations in freshwater fishes is not available. A study of the variations of fat, moisture and protein in two cat fishes and a cyprinid (Sreenivasan and Natarajan 1962) showed that the range of variations of these constituents was narrow, and no seasonal pattern could be noted. *Labeo fimbriatus* introduced into the Bhavanisagar Reservoir in 1954 and in subsequent years has grown well and has attained maturity. It is so successful that in commercial experimental fishing, it is caught regularly. Hence, this fish was taken up for study.

Materials and methods.

The fish caught in the gill nets were never less than 1·5 kg in weight. The procedures described in our earlier publications were followed for analysis.

Results

The results of proximate analysis of *Labeo fimbriatus* for over a year are presented in Table I. Fish of size ranging from 1,589 g to 5,000 g were analysed. These sizes represent the dominant groups occurring in the experimental nets. In the smaller meshed nets, *Labeo fimbriatus* of smaller sizes were not caught. The "condition factor" was calculated from the formula, $K = \frac{W \times 105}{L^3}$ The moisture content of the fish ranged from 72·30 to 84·53 per cent and the fat from 1·05 to 10·81 per cent. The protein also varied greatly—from 10·83 to 21·56 per cent. In figure 1, these three constituents are plotted against months. The vertical lines indicate the fluctuations within that month. For drawing the graph, the mean values were taken.

Discussion.

Highest fat content in individual fish was noticed in August and next highest in July. The former specimen was a female which was in the earlier stages of maturity (probably after spawning in June) while the other specimen was a milting male. But the fat content did not correlate with stage of maturity in either the female or male fish. It was surprising to find highly mature female in the 5th stage and male (milting) right from April 1961 even till February 1962, which indicates no fixed short period for the maturity of fish. This makes the correlation of maturity with fat difficult. There was also no seasonal variation in the fat content. Explaining the large variations in the fat of mackerel, Sohn *et al* (1961) state that "the mackerel are pelagic fish and the variation in the fat may be influenced by the migratory habits". Venkataraman and Chari (1953) as also Vasavan *et al* (1960) explained that the high fat content of Mackerel and Sardines respectively during particular periods was due to intense feeding on plankton. In freshwater fishes such wide variations of fat are not reported probably because these fishes are just local migratory and they do not have to expend as much energy as anadromous fishes like the salmon which store up high fat. For instance, Thurston *et al* (1959) found only limited variations in the fat of lake herring (0·8 to 4·3 per cent), carp (1·0 to 12·5) and Chub (3·3 to 13·1). The fat content of *Labeo fimbriatus* varies from 1·05 to 10·81 per cent. Fat variation in *L. fimbriatus* is not size-dependent. Three fish of weight 1,816 g. had a fat content each 3·8, 4·5 and 1·63 per cent respectively. No variation based on sex, could be observed either. Similar observations were made with regard to halibut by Thurston and Mc. Master (1960). According to Black (1958), fat storage tissues are primarily the muscles and fat is the principal source of energy. Fat furnishes 9 cal/g whereas proteins and carbohydrates provide only 4·0 cal/g. Thus absence of a stable seasonal variation in fat in *L. fimbriatus* may be due to the fact that there is no need for the expenditure of high amounts of energy. The mean values of fat and moisture correlated inversely in *L. fimbriatus* except for a few months. A more defined inverse correlation existed between fat and protein in this fish throughout the year. In fatty fishes, wide variations in protein were not noted (Venkataraman and Chari 1953, Sohn *et al* 1961). But non-fatty fish like *L. fimbriatus* seem to draw upon muscle protein, which steeply falls beginning from June and touching the lowest level in September. Thereafter it increases, reaching the highest in November and falling off subsequently. During periods of low protein, moisture content was high. This tissue hydration indicates starvation or poor feeding conditions and so it is possible that protein reserves are drawn upon during these periods. *L. fimbriatus* is reported Chacko (1956) to breed during the two monsoons. If so, the protein depletion following June and November could be due to the necessity for the post-spawning build up. Love (1960) considers that muscle hydration is greater in larger fish but this is not true in case of *L. fimbriatus*, Likewise the findings of Fish (1960) that larger *Tilapia* had a higher protein than the smaller ones was not corroborated by the data on *L. fimbriatus* presented here.

Average of one years' data shows that the water content of the male was slightly less (77·1 per cent) than that of the female (77·53 per cent) while the protein content of the male was higher (16·12 per cent) than that of female

(15·4 per cent). The female had lesser fat (4·65 per cent) than the male (5·52 per cent) Idler and Bitners (1958) found that the female salmon used up more protein than the males. The lower average for protein in female *L. fimbriatus* may be due to greater utilization in female.

At particular periods very low concentration of protein occurred in *L. fimbriatus* especially from July to October. It is during this period that floods occur and the food is less available. The high water content of the muscle indicates poor feeding. This low protein has a bearing on the nutritive value of fish. Apart from furnishing very low protein content, such fish have a "sloppy" consistency (Love 1958). For any type of processing, fish at this stage is least suitable. The data on the protein content of *L. fimbriatus* is interesting since such low protein content has not been reported for wild fish in literature.

Ackowledgments.

Our thanks are due to Sri V. R. Menon for identifying the stage of maturity of the specimen and to Sri H.K. Ghazi, Director of Fisheries, Madras, for his keen interest in the work and for encouragement.

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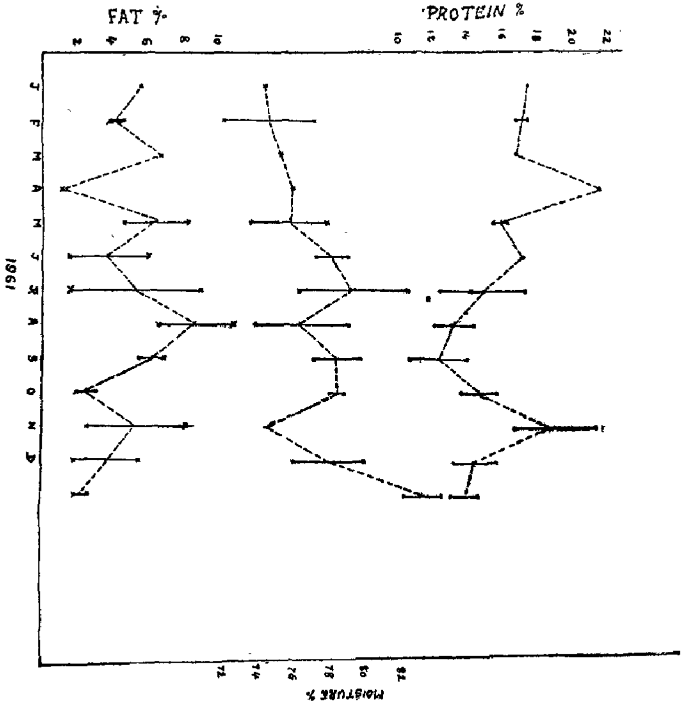
TABLE.

THE VARIATION IN CHEMICAL COMPOSITION OF LABEO FIMBRIATUS.

Serial number.	*Date.*	*Sex maturity.*	*Length.* cms.	*Weight.* G.	*Moisture.* PER CENT.	*Protein.* PER CENT.	*Fat.* PER CENT.	"*Condition factor*" *K.*
			Labeo Fimbriatus (Bhavanisagar).					
1	27th January 1961	♂ IV ..	73·00	4,540	74·6	17·48	5·64	1·17
2	2nd February 1961	♀ IV ..	62·5	3,632	72·3	16·88	4·6	1·49
3	13th February 1961	♂ II ..	51·0	1,816	77·41	17·47	3·8	1·37
4	13th March 1961	♀ IV ..	47·0	1,589	75·47	16·9	6·68	1·53
5	11th April 1961	♀ III ..	52·0	2,043	76·17	21·56	1·05	1·45
6	4th May 1961	♀ V ..	66·0	4,313	73·78	16·39	8·2	1·50
7	19th May 1961	♂ V ..	51·0	1,817	78·03	15·63	4·5	1·37
8	1st June 1961	♀ V ..	50·5	2,043	79·04	..	1·61	1·59
9	14th June 1961	♀ V ..	57·0	2,725	79·43	..	4·47	1·77
10	21st June 1961	♂ V ..	56·0	2,498	77·52	17·31	6·01	1·13
11	5th July 1961	♂ V ..	68·0	4,767	76·58	14·37	8·88	1·51
12	7th July 1961	♀ V ..	53·0	1,817	79·8	17·4	1·63	1·22
13	21st July 1961	♀ II ..	57·0	2,725	82·69	12·55	3·90	1·47
14	8th August 1961	♀ I ..	56·5	2,498	74·00	14·59	10·81	1·39
15	17th August 1961	♂ forming	50·00	1,817	78·37	13·31	7·13	1·45
16	23rd August 1961	♀ forming	54·00	2,271	79·36	12·26	6·55	1·44
17	13th September 1961	♂ spent.	55·6	2,271	77·4	14·12	6·82	1·32
18	20th September 1961	♀ II ..	54·0	2,043	80·0	10·83	5·36	1·29
19	24th September 1961	♀ III ..	69·7	4,540	79·0	13·87	1·96	1·34
20	28th October 1961	♀ spent	68·5	3,859	78·2	15·8	3·03	1·40
21	15th November 1961	♂ ..	55·8	2,300	74·8	21·36	2·54	1·32
22	15th November 1961	♂ Dev.	55·6	2,000	74·82	16·79	8·13	1·16
23	6th December 1961	♂ Milty.	68·5	4,500	81·5	13·35	1·79	1·40
24	13th December 1961	♀ II ..	70·5	5,000	76·19	15·70	5·45	14·27
25	2nd January 1962	♀ V ..	57·5	2,700	84·53	14·70	1·95	14·20
26	19th January 1962	♂ Milting	47·1	1,500	82·43	13·21	2·612	1·435


FAT %
PROTEIN %
1961
J F M A M J J A S O N D
MOISTURE %
72 74 76 78 80 82
2 4 6 8 10
10 12 14 16 18 20 22

USE OF CHLORTETRACYCLINE AS A PRESERVATIVE FOR DRY SALTED FISH—I

BY

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Introduction.

Following the pioneering work by Tarr and his associates (1 to 5) on the use of the tetracycline group of antibiotics in the preservation of fish, much progress has been achieved in retarding the progress of spoilage of fresh, iced and chilled fish by the use of these antibiotics particularly, chlortetracycline commonly known under the trade name aureomycin. The relatively minute concentrations of this substance required to produce effective suppression of spoilage in fish due to bacteria led to great interest in its use by Fisheries technologists all over the world for the preservation of fish and scientific literature is full of reference to work in this field. At present ice containing C.T.C. is widely employed for fish preservation. Similarly, it has been incorporated in chilled sea water, (6) also used for transporting of fresh fish. Velenkar and Kamasastri (7) found that ice containing 5 p.p.m. of C.T.C. enhanced the keeping quality of marine fish packed in it. Visweswariah *et al* (8, 9) found that the keeping qualities of fresh-water fish fillets could be improved by prolonged immersion in C.T.C. solutions and subsequent storage at low temperatures. Sen *et. al.* (10) reported that for salted mackerels a dip in 50 p.p.m. C.T.C. solution before salting appeared to prevent browning of the salted product to a large extent.

Experiments were conducted at the Fisheries Technological Station, Cape Comorin on the use of chlortetracycline as a preservative for four varieties of marine fish cured by the dry salting method. The results of these investigations are presented in this paper.

Material and Methods.

The experiments were conducted with the fishes, *Lethrinus* Silver bellies, sardines and white bait. The specimens procured for these experiments were all caught in boat seines from the inshore waters off Cape Comorin and were processed immediately after being landed ashore. The specimens were washed clean, first with seawater and then with fresh water and processed as follows :—

Lethrinus.

The samples were gutted and filletted. The cleaned fillets were then immersed in a solution containing 25 p.p.m. of C.T.C. for five minutes, drained and salted, the salt-fish proportion being 1 : 4 by weight. After 24 hours the salted fish was drained to remove the self-brine and dried in the sun for three days. A control sample was prepared under identical conditions, but for the dip in the antibiotic solution.

Silver Bellies.

Being small in size, these were not gutted but cleaned by washing only and dipped in 25 p.p.m.C.T.C. solution for one minute. After removing the fish from the dip, the samples were drained and cured with salt under five different salt. fish proportions of 1 : 6, 1 : 7, 1 : 8, 1 : 9 and 1 : 10. The period under cure and the drying time were the same as in the case of *Lethrinus* fillets. Similarly five control samples were also prepared without the C.T.C. dip, other factors being indentical.

Sardines.

For this fish, a salt-fish proportion of 1 : 7 was adopted and the other particulars were the same as for silver bellies.

White Bait.

Two different salt–fish proportions of 1 : 4 and 1 : 5 were tried, the other details of processing the same as for silver bellies and sardines.

The cured products were packed in glass jars with screw caps and periodically examined, once a month for a total storage period of six months. Moisture, total volatile basic nitrogen and trimethilamine nitrogen present in the final products were estimated: T.V.B. and T.M.A. were determined by using an extract prepared by grinding the minced fish with 20 per cent trichloracetic acid and employing the microdiffusion method of Conway. The samples were also organoleptically assayed and test scores awarded to each sample, odour, surface moisure and presence or absence of microflora, based on a key for organoleptic assay of dry salted fish worked out by Venkataraman and Vasavan.[19]

Results and Conclusions.

The results of the periodic analysis are summarised in tables I, II, III and IV respectively for lethrinus, silver bellies, sardines and white bait.

It was found that in the case of *Lethrinus*, silver bellies and sardines, the C.T.C. treated products retained excellent quality for the first three months in storage, whereas the corresponding untreated control samples had retained comparable quality only for the first two months of the period of storage. This was evident from the T.V.B. and T.M.A. values and also on the basis of organoleptic assessment of the samples. In the case of the cured white bait alone, the antibiotically cured products were in excellent condition up to the end of the fifth month in storage and even at the end of six months they were quite good. The degree of spoilage in the C.T.C. treated samples of white

bait at the end of the five month storage period was comparable to that in the untreated control samples, at the end of a three month storage period. The enhanced keeping quality of the white bait over the other fishes tried is attributable to the relative superior quality of the starting raw materials and due to certain other chemical factors. In general it was observed that with all the four fishes experimented with and for the different salt : fish proportions tried, the C.T.C. treated products were superior in quality to the corresponding control samples at every stage during the period of storage of six months. The shelf life of dry salted fish could be enhanced by about fifty per cent over that of the ordinary cured products by the application of chlortetracycline before the application of salt for curing of marine fishes, by the method described above.

Considering the great benefits by the adoption of the method of curing described, to the fishing industry especially in India, where the chief method of fish preservation is by salting, the cost of the antibiotic, which is required only in relatively very minute quantities, will be quite negligible and more than compensated for by the improved keeping qualities of the cured products Further, this will result in the provision of more wholesome protein food for the country's millions whose diet is badly deficient in protein.

Chari[13] found that in *cybium* fillets dipped for one minute in 20 p.p.m. C.T.C. solution and kept in cold storage (3°C) for seven days, the C.T.C. absorbed by the fillets was completely destroyed by heating at 70°C for ten minutes and at higher temparatures for shorter intervals. Thus, under ordinary conditions of cooking the C.T.C. in the antibiotically treated fish is completely removed and hence there cannot be any objection to the use of this preservation for cured fish on the ground that residuary antibiotic in the fish might be injurious to health.

The method of curing fish using aureomycin as a preservative is recommended to the fishing industry for adoption.

Further investigations on the use of C.T.C. as a preservative for the salt curing of other economically important marine food fishes are in progress, the results of which will be published later.

ACKNOWLEDGMENTS.

I wish to express my thanks to Sri S. T. Chari, Superintendent, Fisheries Technological Station, Tuticorin for his guidance and suggestions during the conduct of these investigations.

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Annexed : Four tables consolidating the data.

TABLE I.—*Data on progress of spoilage in letherinus Fillets cured with salt after treatment with C.T.C. (Salt fish=1:4).*

Number of days in storage.	Dried.		30		60		90	
Sample,	A	B	A	B	A	B	A	B
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Moisture per cent	49·00	38·98	39·63	36·17	37·10	36·20	36·00	36·10
T.V.B.N. (mgm./cent)	81·20	74·80	81·60	76·00	84·80	80·00	92·80	85·60
T.M.A.N. (mgm./cent.)	70·00	60·80	68·80	64·00	72·40	68·40	72·00	68·80
Organoleptic Test Score (max. 30)	29·00	30·00	29·00	30·00	28·00	29·50	28·00	29·00

Number of days in storage,	120		150		180	
Sample,	A	B	A	B	A	B
	(10)	(11)	(12)	(13)	(14)	(15)
Moisture per cent	38·42	37·24	41·52	39·39	36·90	33·72
T.V.B.N. (mgm./Cont.)	123·00	97·00	173·00	128·50	204·00	172·00
T.M.A.N. (mgm./Cont.)	81·50	71·50	95·00	73·00	101·00	77·00
Organoleptic Test Score (max. 30)	25·00	27·00	22·00	25·00	20·00	24·00

Remarks—
A—Control Sample.
B—C.T.C. Treated sample.

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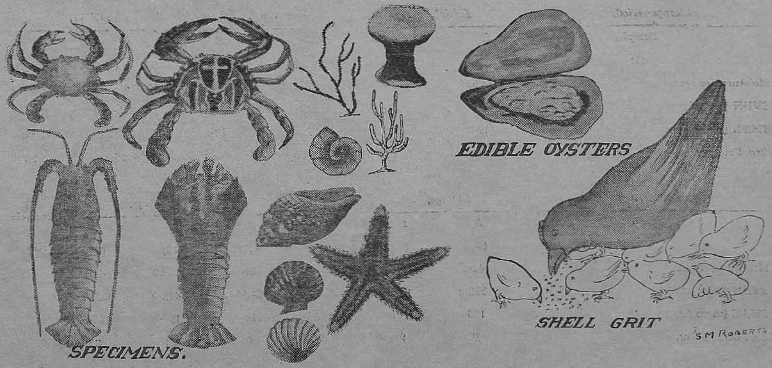

TABLE II—*Data on progress of spoilage in Silver Bellies cured with salt after treatment with C.T.C.*

Months after storage.	*Sample.*	*Control,* Salt : Fish. 1 : 6	1 : 7	1 : 8	1 : 9	1 : 10
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Initial	Moisture per cent	29·20	27·96	25·42	26·60	27·4
	TVBN (mgm./cent)	192·80	208·00	259·20	254·40	304·0
	TMAN (mgm./cent)	78·40	79·2	81·6	88·0	137·2
	Org. Score	28	28	27	27	25
First month	Moisture per cent	29·3	28·0	25·40	26·6	27·26
	TVBN (mgm./cent)	196·0	212·8	268·8	274·4	304·0
	TMAN (mgm./cent)	80·8	80·0	92·8	92·8	148·8
	Org. Score	28	27	22	22	20
Second month	Moisture per cent	34·06	30·52	29·26	32·14	30·86
	TVBN mgm. per cent	224·0	222·0	300·5	312·0	356·0
	TMAN mgm. per cent	85·0	91·0	121·5	127·0	163·5
	Org. Score	26	27	20	19	17
Third month	Moisture per cent	32·24	30·08	27·72	28·33	27·18
	TVBN mgm per cent	262·0	260·0	368·0	396·0	421·0
	TMAN mgm. per cent	96·0	94·0	158·0	161·0	188·0
	Org. Score	23	24	17	18	13
Fourth month	Moisture per cent	35·87	35·99	32·00	29·14	35·67
	TVBN mgm. per cent	318·0	310·0	380·0	411·0	425·0
	TMAN mgm. per cent	114·0	116·0	168·0	164·0	197·0
	Org. Score	18	19	14	14	11
Fifth month	Moisture per cent	35·64	36·29	31·13	28·90	35·26
	TVBN mgm. per cent	335·0	316·0	380·0	410·0	425·0
	TMAN mgm. per cent	115·0	116·5	169·0	166·0	196·5
	Org. Score	17	19	13	14	10
Sixth month	Moisture per cent	36·10	36·41	31·80	30·20	34·82
	TVBN mgm. per cent	372·0	360·0	394·0	450·0	448·0
	TMAN mgm. per cent	121·0	124·0	178·0	197·0	201·0
	Org. Score	16	17	13	13	9

TABLE III—*Data on progress of spoilage in Sardines cured with salt after treatment with CTC (Salt : Fish—1 : 7 by weight.)*

Storage period. *Sample.*	*Initial.* A	B	*30 days.* A	B	*60 days.* A	B
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Moisture per cent	42·61	41·88	40·84	41·60	40·18	41·40
TVBN (mgm./cent)	212·5	171·5	267·5	210·0	320·0	225·5
TMAN (mgm./cent)	149·5	78·5	175·0	91·5	146·5	105·2
Org. Score (Max. 30)	28	29	28	29	25	23

Storage period. *Sample.*	*90 days.* A	B	*150 days.* A	B	*180 days.* A	B	*Remarks.*
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Moisture per cent	40·00	41·41	40·60	41·08	40·08	41·16	
TVBN (mgm./cent.)	322·0	222·0	384·0	242·0	412·0	248·0	
TMAN (mgm./cent.)	136·0	107·0	184·0	114·0	180·5	120·0	
Org. Score (Max. 30)	20	25	17	24	13	22	

A—Control sample.
B—CTC Treated sample.

TABLE II—*Data on progress of spoilage in Silver Bellies cured with salt after treatment with C.T.C.*—cont.

Months after storage.	*Samples, Salt : Fish.*	*C.T.C. Treated.* 1 : 6 (8)	1 : 7 (9)	1 : 8 (10)	1 : 9 (11)	1 : 10 (12)
Initial	Moisture per cent	30·31	29·49	29·26	26·97	25·99
	TVBN (mgm./cent)	110·4	114·0	141·2	211·2	211·2
	TMAN (mgm./cent)	47·6	67·2	78·4	91·2	104·8
	Org. Score	30	30	29	28	27
First month	Moisture per cent	30·24	29·5	29·25	27·0	26·14
	TVBN (mgm./cent)	111·2	114·8	114·0	212·8	217·6
	TMAN (mgm./cent)	47·6	63·8	77·6	121·6	130·0
	Org. Score	30	30	29	25	25
Second month	Moisture per cent	34·03	32·34	31·30	31·36	33·98
	TVBN mgm. per cent	125·0	128·0	161·0	240·5	246·0
	TMAN mgm. per cent	77·5	72·5	89·0	126·0	128·0
	Org. Score	30	30	28	25	24
Third month	Moisture per cent	32·16	31·10	30·25	31·06	29·65
	TVBN mgm. per cent	146·5	150·5	174·0	286·0	300·5
	TMAN mgm. per cent	84·25	105·0	97·0	151·0	155·5
	Org. Score	25	25	24	22	19
Fourth month	Moisture per cent	37·47	31·82	35·22	33·14	36·46
	TVBN mgm. per cent	184·0	180·0	183·0	288·0	324·0
	TMAN mgm. per cent	92·0	104·0	101·0	153·0	162·0
	Org. Score	23	23	21	19	18
Fifth month	Mositure per cent	36·17	31·86	35·24	33·35	36·29
	TVBN mgm. per cent	184·0	182·0	184·0	289·0	332·0
	TMAN mgm. per cent	91·0	104·0	101·0	167·0	166·0
	Org. Score	22	22	19	17	16
Sixth month	Moisture per cent	35·18	31·88	35·60	34·64	36·54
	TVBN mgm. per cent	198·0	208·0	206·0	284·0	342·0
	TMAN mgm. per cent	90·0	106·0	104·0	170·5	176·0
	Org. Score	22	22	18	16	14

TABLE IV—*Data on storage studies on CTC Treated Fish—White-Bait.*

Salt Fish.	*Period of storage (days.)*	*Control sample.* *Moisture.*	*TVBN*	*TMAN*	*ORG score.*	*CTC Treated sample.* *Moisture.*	*TVBN*	*TMAN*	*Org. score.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 : 4	60	30·48	134·0	60·5	28·0	31·20	108·0	48·0	29·0
	90	30·62	144·2	61·2	27·0	31·06	112·75	52·0	28·0
	120	30·80	153·0	63·0	26·0	31·08	120·0	55·5	28·0
	150	30·14	164·0	64·75	24·0	31·61	127·5	58·0	27·0
	180	30·68	186·0	70·0	21·0	32·40	147·5	63·0	24·0
1 : 5	60	31·12	138·0	61·5	27·0	31·30	110·25	50·25	29·0
	90	32·00	148·6	63·8	27·0	31·42	116·0	51·6	28·0
	120	31·60	155·5	64·0	26·0	30·60	121·0	54·0	28·0
	150	32·08	165·0	67·5	24·0	31·26	126·0	57·5	27·0
	180	32·42	185·0	72·0	21·0	33·08	144·0	64·0	24·0

Remarks.—(1) Moisture as per cent.

(2) TVBN and TMAN as/mgm./cent.

(3) Org. Score out of a maximum of 30.

USE OF TURMERIC AS A PRESERVATIVE FOR DRY SALTED WHITE-BAIT FISH.

BY

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I. Introduction.

Salting is by far the most important and extensively employed existing method for the preservation of fish in India. But owing to various factors such as non-availability of good quality salt, defective and inadequate curing methods and lack of proper storage facilities, the cured fish seldom keeps in good quality by the time it reaches the consumer. More often than not, the cured fish sold in our interior markets is in too advanced a stage of putrefaction to be fit for human consumption. Observations on commercially cured fish from fish-curing yards and fish markets in Malabar and South Canara Districts (Venkataraman and Vasavan—1955) as well as similar studies conducted by others on commercially cured fish in India revealed that the condition of the products was far from satisfactory, (Nicholson, 1905 Venkataraman 1951, Velankar, 1952; Venkataraman *et al*, 1954). The use of salt of greater purity and addition of various chemical preservatives have been suggested by various workers in the field in order to improve the quality of cured fishery products. Because of practical difficulties in adopting these methods' it was thought worthwhile to try the use of some simple indigenous preservative that could be mixed with the salt used for curing of fish. It was in this connection that investigations were taken up on the effect of turmeric added to salt used for curing of fishes. Turmeric is an essential condiment used in the preparation of a large number of dishes of the Indian menu. It is a common practice for the housewife to add, a little bit of ground (fresh or dried) turmeric along with salt when fresh-water fishes caught in excess of daily requirements from the rivers are to be preserved for the next day or two for consumption. The results of investigations carried out by the author on the effect of addition of varying percentages of turmeric powder to salt used for curing the marine fish, white-bait (*Anchoviella heteroloba, A. Zollingeri and A. Commersonii*) are presented in this paper. This particular fish was chosen as it contributes to an economically important fishery in this region and the existing method of preservation of this fish by mere sun drying as practised by the local fisher-folk is far from satisfactory. It was also observed that when merely salted and dried white-bait was kept in storage it started crumbling to pieces in about two months' time unlike other fishes having relatively more of fibrous tissue than this fish.

II. Materials and methods.

Venkataraman and Vasavan (1955) showed that a salt to fish ratio of 1 : 5 or 1 : 6 was adequate to ensure good keeping quality for dry salted white-bait from the west coast. For the present study a salt to fish ratio of 1 : 5 by weight was chosen. Freshly landed fish was purchased for these experiments from the catches of boat seines landed at Cape Comorin. The fish was cleaned well by washing and was cured under controlled conditions with crushed salt mixed with commercial turmeric powder, available in the market packed in paper cartons and sold for domestic use, so that the percentage of turmeric in the salt-turmeric mixture used for curing the fish varied from 0 to 15 by weight. The period under cure was 24 hours and the period of drying (By Solar heat) was 12 hours. The salt used was the same as issued from the local fish curing yards for curing fish. The cured products were stored in deal wood boxes lined with paper and samples were examined organoleptically and chemically after storage for 15, 30, 45, 60, 90 and 120 days, by taking representative samples from each lot.

Moisture was determined according to A.O., A.C. method of analysis on the entire finely ground fish. Estimation of total volatile basic nitrogen was carried out with the whole ground fish according to Okoloff's magnesium oxide distillation method as adopted by Lucke and Ceidel (1932) and recommended by Winton and Winton (1947). Organoleptic evaluation of the samples was conducted by noting the appearance, texture, flavour, odour, surface moisture and presence or absence of mould growth. The key for organoleptic assay of salted fish based a numerical scoring system worked out by Venkataraman and Vasavan (1955) for west coast fishes was adopted for these experiments with slight modifications.

III. Results and discussions.

Six samples of white-bait were cured with salt and turmeric, the percentage of the turmeric in the mixture being 2, 3, 4, 5, 10 and 15. A control sample was cured with salt alone. The results of the experiments are given in Table I. The variation of total volatile basic nitrogen in the samples on storage for 120 days is graphically represented in Figure I where curve A shows the change in T.V.B.N. values for the control sample. In the samples cured with mixtures of salt and turmeric the levels of T.V.B. Nitrogen were much less than in the control sample and these were proportionately less with the increase in the percentage of turmeric added but for slight deviations towards the fag end of the storage period. This is evident from the curves, B, C, D, E and F in figure I. These findings will be further verified from figure II where the T.V.B.N. values at the various intervals have been plotted against the percentage of the condiment in the salt turmeric mixtures used. These prove that the presence of turmeric along with the salt used for curing white-bait enhanced the keeping quality of the cured products. It was seen that with increasing percentages of turmeric the final products contained relatively less amounts of total volatile basic nitrogen at different intervals during storage. In other words spoilage had not taken

place to the same extent in products obtained with salt-turmeric mixtures as in those treated with salt alone; and the extent of spoilage was, in general progressively smaller with increasing quantities of turmeric added. But taking into consideration the general appearance of the product from the point of view of marketability and consumer appeal, it was found that more than 5 per cent of turmeric was not advisable as with a higher percentage the characteristic colour, odour and flavour due to excess of turmeric became very evident masking the fishy odour and flavour.

IV. Conclusions.

The incorporation of about 5 per cent by weight of turmeric mixed with salt used for curing white bait results in a better product with enhanced keeping quality than products obtained by processing with salt alone. The preservative action of turmeric appears to be due to some bacterio-static principle present in it and responsible for inhibiting the growth of fish spoilage bacteria.

The method of curing described is recommended for adoption by the fishing trade for salting white bait to obtain a better product of superior keeping quality for human consumption and to prevent the huge wastage of this valuable protein food resulting from the inadequate methods of preservations now employed.

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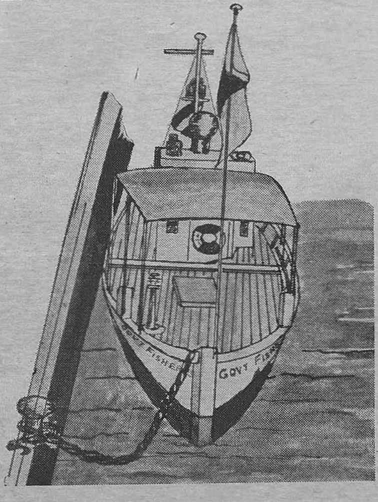
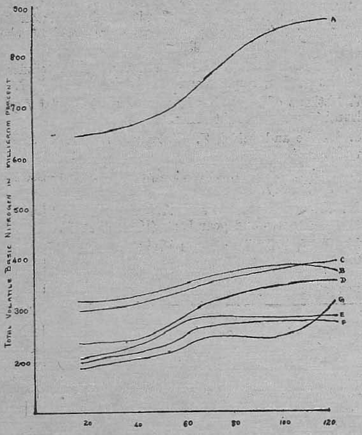
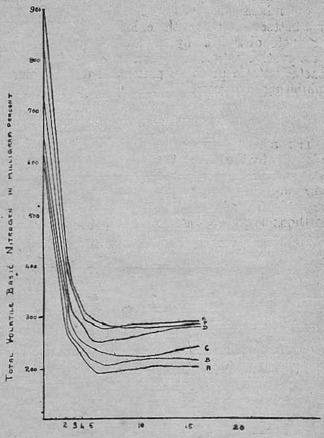


VISIT
FISHING HARBOUR AT
CUDDALORE.



Storage period in days.

FIG. I—Graph showing effect of different quantities of turmeric added to salt used for curing White-Bait on total volatile basic Nitrogen content of cured products during storage for 120 days. A—control sample cured with salt alone; B. C. D. E. & F.—Samples cured with Salt—Turmeric mixtures containing 2% ; 3% ; 4% ; 5% ; 10% and 15% respectively of turmeric powder.



% By Weight Turmeric in Salt—Turmeric Mixture.

FIG. II—Graph showing variation of T. V. B. N. with percentage of Turmeric added to salt used for curing White-Bait for storage periods of 15 days (cure—A), 30 days—(B), 45 days (C), 60 days (D), 90 days (E) and 120 days (F).

CATCH—EFFORT OF INDIGENOUS FISHING CANOE IN THE PALK BAY

BY

P. I. CHACKO.

The Palk Bay is the shallow sea between India and Ceylon, north of the Pamban Pass. The average depth is about 5 fathoms. The bottom is muddy. The common fishing canoe of this region is of a distinct type of the outrigger class. The outrigger consists of a long and heavy plank laid athwart so that each end projects outboard a considerable size on either side. By loading the projecting section on weather side with one or two members of the crew a very efficient counterpois is obtained. The canoe is about 35 feet in length and 5 feet broad and 3 feet deep. A main mast is employed for propulsion and less frequently a mizzen in addition. The characteristic feature is the presence of a pair of quarter steering-boards instead of a fixed rudder.

The catch-effort efficiency of such a typical fishing boat was studied with Adirampatnam as base, for one year from April 1959 to March 1960. A crew of five and a set of 15 gill-nets were employed. The quantity of fish captured and the sale-proceeds during the twelve months were as shown below :—

Month.	*Number of fishing days.*	*Quantity of fish caught.*	*Sale-proceeds.*	
		LB.	RS.	NP.
April ..	25	4,538	698	90
May	26	3,197	477	71
June	26	2,605	358	84
July ..	24	2,488	244	29
August	26	3,989	452	57
September	22	3,330	414	85
October	11	4,456	681	80
November	5	214	39	18
December	22	1,096	173	35
January	14	1,018	148	54
February	19	2,036	306	04
March	24	2,826	439	74
Total ..	244	31,793	4,435	00

The catches were good from January to August when south and south-west winds prevailed. With the onset of the north-west winds, the catches improved in the months of September and October. But when rain and cyclonic conditions prevailed from November to January, fishing was not favourable. The conditions improved in February and March. The catches consisted of skates, rays, saw fishes, cat fishes, leather-jackets, jew fishes hilsa and others.

The catch-effort of the canoe and the crew, quantitatively and qualitatively are given below :

Month.	*Catch per day.*	*Sale proceeds per day.*		*Catch per day per fisherman.*	*Income per day per fisherman.*	
	LB.	RS.	NP.	LB.	RS.	NP.
April	181·72	27	92	36·34	5	58
May	123·00	18	37	24·74	3	67
June ..	100·18	13	80	20·04	2	76
July	103·66	10	18	20·73	2	03
August	153·42	17	40	30·68	3	68
September	151·36	18	85	30·27	3	77
October	405·09	61	98	81·02	12	39
November	43·80	7	83	8·76	1	66
December	49·81	7	88	9·96	1	57
January	72·72	10	62	14·54	2	12
February	107·15	16	14	21·43	3	23
March	117·74	18	32	23·25	3	66
Average for the year	130·29	18	17	26·06	3	65

The average catch per day of fishing by the canoe varied from 43·80 lb. in November to 405·09 lb. in October. Excepting the cyclonic months of November, December and January the catch per day exceeded 100 lb. The sale proceeds per day varied correspondingly from Rs. 7·83 in November to Rs. 61·98 in October. The catch and income per fishermen per day varied from 8·76 lb. and Rs. 1·56 to 81·02 lb- and Rs. 12·39. The average per day for the whole year was 26·06 lb. and Rs. 3·65 per fisherman.

This study has helped to work out the economics of fishing operations by indigenous craft and gear.

FISHING METHODS OF SCOMBROIDS IN MADRAS COAST

BY

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The fishes of the Scombroid group form an important fishery in the Madras Coast esteemed as economically important. Seer is to-day the most priced fish valued as a class table variety. Tunas have potential value though are landed in lesser quantities now, compared to Seer. But this gives ample promise to improve the landings in the future. Mackerel is yet another group which forms an important fishery in certain selected centres during the season. But along the East coast the fish is not caught in such large quantities as in the West Coast. The Bill fishes, predominantly a deep water variety are rarely caught in Trolling lines. This fish is not considered as economically important in Madras State.

The Madras Coast could be broadly classified into—

(1) the Coromandel Coast which extends from Madras south-ward up to Point Calimere. The coast line is mostly surf beaten and has steep gradient in the depth. Catamarans are the common craft used; large masula boats are also operated for shore seines in some places;

(2) The Palk Bay Coast commencing from Point. Calimere extends up to Dhanushkodi. The Bay is mostly of even depth with a maximum depth of 9 fathoms. The depth gradient is very gradual like a shallow plate. The sea bed is mostly of soft mud except for the coral beds off Rameswaram up to 6½ fathoms;

Mookur type vallams and round bottomed Carvel built shallow boats of Thondi type are the common crafts;

(3) the Gulf of Mannar extends from Dhanuskodi towards west and south up to Kanyakumari. The sea coast is rugged and is surf beaten along the beach south of Tuticorin. The various pars and coral reefs in this sea afford good possibilities for fishing on rocky bottom. Canoes are used up to Tuticorin and 3 logged boat catamaran are operated in the rugged southern coast line; and

(4) the Kanyakumari Coast extends into the Indian Ocean which has a steep gradient of depth extent for a few sheltered bays. The coast line is mostly surf beaten and is reputed for the reefs near the shore line.

Catamaran is the common craft used in this coast.

Seer

Seer is a well known Scombroid and is largely caught in the Gulf of Mannar and Palk Bay. Of the two common varieties known, *C. Guttatum* and *C. Commersoni*; the former is more commonly available and is landed in large quantities. *S. eneslatus* is also found in the catches specially in the Palk Bay region.

Being a variety more commonly found along the surface and upper column the most effective gear, used commonly to land this fish is the 'Drift Net' operated mostly from the Tuticorin and Mookur type canoe. The average size range landed in Drift nets is 2–9 lbs. Large-sized seer weighing above 10 lb up to about 50 lb are landed mostly in 'Trolling lines'.

The 'Drift Net' is a set of Gill nets usually 20 fathoms long and 6½–7 fathoms deep. The mesh size range from 3″–4½″. *In recent times the net is constructed with* Synthetic fibre of breaking strength 35—40 lb. (commonly) and Dunlop twine of which this gear was made of even three years back has become almost obsolete.

To the upper edge is fixed one mesh selvage of thick material which is about two times the mesh size and carries usually 3 meshes in it, left loose.

The head rope, usually of 4 Ply 3/4″ thick hard twisted coir is passed through the thick selvage mesh and the meshes are made fast at intervals of 1–1½ fathoms leaving 14 or 16 selvage meshes in between, to give 40 *per cent*—50 per cent framing. Usually the nets are framed a little stretched in the Palk Bay compared to the Gulf of Manar nets.

No ground rope is used. 15–18 such nets form a '*Set*'. Wooden floats of light timber about 3″×9″ are used as floats fixed on snoods of about 1 foot at intervals of 1–1½ fathoms. Small stone sinkers are fixed at intervals of 4–6 fathoms joined to the lower edge of the net, and the number of sinkers varies according to the *force* of current and depth operated.

The canoes sail out in the evening and set their gear at dusk. From the set, lead a long thick net warp of about *30 fathoms by which the canoe is attached to the* set and drift. The net is hauled up once after mid-night and re-laid. At day break the set is hauled in and the canoes return ashore with the catch. Seer and Sabre fish are the usual catch for this gear though *Caranx, Chorinemus*, Sharks, etc., are also landed. In the Gulf of Mannar, Seer is caught in large number between September and January. This fish is landed in considerable quantities in the Palk Bay with this gear from March–August. The Seer caught with the Drift net are usually small sized weighing up to 10 lb. and mostly belong to C. guttatum and *Scomber lanceolatus*.

In the Gulf of Mannar the large sized Seer usually *C. commersoni* are landed in Trolling line. Seer of 10–50 lb. *is common for this gear mostly during* September and October.

In the Coromandel coast Seer are not landed in large quantities as compared to the Gulf of Mannar and Palk Bay. The Drift net is not much developed in this zone. Those used are only 10-12 fathoms long and are about 3-4 fathoms deep. Ten such nets are usually operated from a catamaran.

Here again, the large-sized Seer, is caught in the trolling line operated from the catamaran while returning from other types of fishing in September-November. Thus it would be observed that the Seer Fishery is not very important in this area compared to the Palk Strait or the Gulf where this gear for Seer is more effective and widely used.

In the Kanyakumari Coast Seer is caught in smaller quantities by the Drift nets which again is about 4½ fathoms deep. 10-12 nets of 12 fathoms are operated from the catamaran. But often good quantities of *C. guttatum* are landed in the Shore seine from August to September in the Northern Coast of the district.

Seer, as already stated is commercially the most important Scombroid. This is greatly priced as a table fish. Cured Seer (Keelam) is valued in Ceylon and mostly 'Tub cured'. Pit cured Seer is sold in inland markets only.

Seer is popularly called "Seela", "Naimeen", "Vanjiram", "Mavilasi" and "Arikula" in different places along the coast line.

The fish gets easily tainted and it is very difficult to land all the catch in fresh condition.

Mackerel.

The second important fishery of the group known commonly is the Mackerel (*Rastrelliger Canagurta*). This is popularly called in the local language as "Iyla", "Kananketuthi" or "Kumbla." Mackerel is a pelagic fish mostly found in shoals and migrates closer to shore during the seasons.

Along the Kanyakumari Coast in places like Thengapattinam, Thoothur, etc., Mackerel are landed in fairly good quantities in shore seine net during August-October when the south-west monsoon had dwindled down. Further north in the Gulf of Mannar along the Idinthakarai Coast mackerels are landed in the bag nets between November-January fairly close to the coast in 7-12 fathoms. Very often mackerels are landed in smaller numbers in the drift nets of 3" mesh along with seer and sabre fish off Tuticorin and Manapad. Tracing north-east, from Tuticorin along the coast, mackerel is landed in good numbers in the shore seine operations at Valinookam and in the Gulf islands during October-December.

Mackerel is landed more predominantly at the Dhanushkodi coast from November-February where large quantities are sometimes caught. fifteen to twenty thousand Mackerel have been landed in Shore seine at Dhanushkodi during these months. The most effective or common gear by which mackerel is landed in large quantities is the Kara Valai in the Gulf of Mannar, Coromandel Coast and in the Kanyakumari district.

The *Kara Valai* meaning "Shore net" of the Palk Bay and Gulf of Mannar are identical in design though the one operated in the Gulf is provided with a bigger bag and higher wings (Marukku).

The 'Karavalai' consists of a cod end of thick cotton (20×15) of ½" mesh 4 fathoms in circumference. The whole bag is 7 fathoms deep from the mouth to the bunt. Next to this bag on either side are laced the wing pieces which are also of cotton 9 fathoms high and 15 fathoms long made of ½" mesh.

Next to this cotton wing piece on either side are joined 6 portions of coir wings, the mesh size of which increase progressively from 6" to 90" from the centre towards the free end which is 215 fathoms long. To this is attached the warps, coils of coir rope of each 60 fathoms long and 1" thick.

In the operation the whole net is loaded in a boat and the end of one of the warps is left in the shore and the boat carrying the net move away from the shore forming an arch, and as the boat moves the net is paid out in such a way that the bag comes in the centre of the thus enveloped area and the other end warp is brought to the shore away from the first warp end.

The distance up to which the net is expected to operate depends on the number of warp coils used in the operation. The shore seines are normally operated up to about one mile from the beach and fishes that are enveloped inside the arch formed while setting the net are hauled up and collected in the bag.

In the Palk Bay, a few Mackerels are landed in the Drift nets along with other fish occassionally and not occur as a regular fishery in good quantities.

Along the Coromandel Coast Mackerels are landed in large numbers north of Nagapattinam. The appearance of Mackerels along this coast is between February-May. During this time mackerels are landed in fairly good quantities in the Drift net used specially in the nets of 3" mesh size and less. Along the Pondicherry and Cuddalore Coast Mackerels are also landed in the "Edavalai" during April and May, when a maximum of 500-600 numbers are landed in a single operation.

North of Pondichery, in the Madras Coast Mackerel is mostly landed in the "Shore Seine" net "Periya valai" This is the most effective gear along this coast when 5,000-6,000 numbers are landed in a single operation during April and May when the north-east monsoon is subdued. The "Periya valai" used in the Coromandel Coast is similar to the Shore seine already described except for the bag which is tapered into a cylinderical bag.

Along Pondichery, Marakanam coast, Mackerel is also landed occasionally during the months of August-September in "Edavalai" and in the shore seine 'the Periya valai'.

Mackerel also occupies a place of economic importance in the fishery of East Coast, though it is not so marked as in the West Coast of India.

As a Table fish, Mackerel occupies a place of lesser importance compared to the Seer. But cured Mackerel is well in demand specially among the working classes of inland districts and the up-country estate labour.

Tunas form yet another large group among the scombroids, though not so commonly known as the Seer or Mackerel being mostly a deep water variety.

Three varieties of Tunas are known in the fishery of Madras Coast :—

(1) *Euthynnus affinis*	.. ..	" Soorai " (Tamil)
(2) *Kishinoella tonggol*	..	" Kilavalai "(Tamil)
(3) *Neothunnus Macropterus*	..	" Ettalai " (Tamil)

Of the three twine Tunas *Euthynnus sp.* is more commonly known to the fishermen than the other two varieties mainly because of their occurrence shore ward.

" Soorai " (Tamil) *Euthynnus affinis*, the smaller number of the group and most commonly landed of all the Tuna members. On the average *E. affinis* weighs 8–15 lb.

In the Kanyakumari Coast this also occurs in the Bottom Set nets of Nylon mostly in 6″ nets in 15–20 fathoms depth. On certain occasions during August and September about 1,500 lb. have been landed in a set. In the Coast of Thengapattinam, Enayam, Puthenthurai, Thoothur, etc., this is caught in shore seine net called " Peru valai ".

Tracing north in the Gulf of Mannar *E. affinis* are landed in the 'Pachu valai', local set net, off Idinthakarai Manapad, etc., in 15–20 fathoms during August to October. These nets are made of thick hemp and are of 5–6″ mesh size. However, these have been now replaced by nylon material.

Off Tuticorin and Sippikulam, Kilakarai, etc., " Soorai " is caught in the Drift net as well as in the Trolling line, which is like a game fishing tackle. Mostly big Seer and the bigger members of the Tuna group are landed in the Gulf of Mannar in trolling lines only.

The fishermen in the Gulf of Mannar specially those of Tharuvaikulam who are specialists in trolling line fishing use Carvel built sailing boats of 32–34 feet which have good sailing speed. Special hard twisted lines of about 4 m.m. thick and 30 fathom long are used as the line. No. 1 hooks are used mostly, attached to the line by a shining German Silver and Copper wire snood of about 1 fathom length. The hook is usually hid by a tuft of lure fibre tied at the stalk of the hook to which the full bait, Sardine or Mackerel is hooked and tied to resemble a live fish on the move.

In the Kilakarai area, specially made flattered hooks with longer stalks are used instead of the standard mustered hooks as the fishermen believes that the special hooks have better catching power and help to keep the bait straight.

A typical trolling canoe is a Tuticorin type boat about 32 feet long. It carries mostly a single mast and a lug sail. Provision is also made in the boat for a second aft mast to carry an additional sail if required. The canoe usually carries heavy ballast of sand bags to counteract the litting by the sail.

The bamboo poles are carried on either side of the canoe to which the trolling lines are attached. Usually 4 lines are carried on each bamboo or either side of the canoe. From the sail yard is drawn a line to the stern and to this is attached a line. Thus on an average 9 lines are carried in a " troller canoe ". The canoes set sail to the ground in the morning and reach the fishing ground usually about 16–20 fathoms and look out for indication of schools of big fish viz., Tuna, *Caranx*, Seer or *Chorinemus* and set the baited line and set sail in the favourable direction.

When the lines start fishing the crew in charge of the line haul up the line with maximum speed and reset. The canoes usually change the course and run in such a way that the lines are dragged in an area where the catch occurs and the speed of the canoe is usually kept uniform adjusted to the speed in which the first fish was caught that day.

Off Kilakarai, the Trolling boats are the typical Keelakarai or Thondi type with round bottom, narrow beam with balance beam and raised bow. The popularly called " Kulla Dhoni " are the out-rigger canoes operating off Kilakarai which specialise in trolling lines.

The trolling line fishermen have given typical names to the individual lines towed and this helps the skipper to alert the crew to take care of a particular line which has caught the fish and thus no time is lost.

The lines on the port side boom are named (1) Kuttia, (2) Parai, (3) Kalal Kuttia and (4) Mukku Kuttia respectively and the lines on the star board side boom are termed (1) Kotta, (2) Kandha, (3) Emden and (4) Kuttia. The line on the sail boom rope is called Etta Kalai.

When the lines start fishing the skipper gives tak on the starboard or Port side as the case may be to ease the strain on a particular side line and shouts the name of the line in which the fish is caught. The crew who is in charge and is allotted the particular line immediately is alerted to attend to the particular line.

Whiffing line fishing off Tuticorin and in the area north of Gulf of Mannar is very effective during the months of August, September and October.

Catches are usually, *Thunus* sp., Seer, *Caranx*, *Chorinemus, etc.*

Best catches are observed to be between 8 a.m. to 10 a.m. before the sun becomes warm. The hook lure used by the Tuticorin trollers and the shining snoods are believed to attract the fish from long distances which chase and catch the bait on the move.

By this gear the bigger Tunas are also landed specially in the grounds close to deeper waters 10–15 miles from the coast.

Occasionally *E. affinis* is landed in the shore seines off Ramnad Coast, while operating south of the island rows in the Gulf of Mannar. Up to 200 numbers have been recorded in a single haul, each weighing about 10–15 lb. In the Palk Bay *E. affinis* is totally unknown. The Drift netters and set net fishermen have not landed this fish. However, in certain grounds close to Thalaimannar in the Ceylon Coast and north-west of Jaffna this species has been landed in drift nets of bigger mesh size. These are called in Ceylon " Bhalliya ".

In the Coromandel coast *E. affinis* is also landed in Trolling lines and long line. The catamaran fishermen who return from other types of fishing usually set out 3–4 lines when they make the homeward journey and in this Tuna is caught. This is locally called the " Mela Kada Soorai " because it is landed in deeper waters and are caught along with sail fish, seer, etc. During August, September and October, off Madras fishermen operate long line with No. 4 and 5 hooks baited with squid. Four hundred hooks are laid by a catamaran in 15–20 fathoms when this fish is caught in better quantities.

The bigger members of the Tuna group caught in Madras coast are *Neothunnus macropterus* and *Kishinoella tonggol* popularly called " Ettalai " and " Kilavalai " respectively. These fish weigh 40–100 lb. and are very fast swimmers occurring in fishing grounds adjacent to deep waters. In Kanyakumari district *K. tonggol* is even landed in the shore seine net in the fishing villages of Thengapattinam, Thoothur and Enayam Puthenthurai during September-October. When schools of the bigger varieties are noticed and the fishermen get ready for encircling the bigger Tunas, they usually fix a strong bag or bunt to their shore seine made of twisted rope of about 3 m.m. thick in 5″ mesh size.

In the Gulf of Mannar *N. macropterus* and *K. tonggol* are commonly landed only in whiffing line. Mackerel is the bait that attracts this fish better. Tuticorin and Kilakarai Trolling fishermen carry strong lines for this fish and good numbers are landed during August–October.

The Palk Bay is devoid of this fishery.

In the Coromandel coast, *T. macropterus* is landed mostly in whiffing lines in 15–20 fathoms. But this is also caught in the long line set baited with squid. No. 4 or 5 hooks are used and a set of 400 hooks are used set higher in the column by adjusting the boats.

Tunas do not have much of market value as a table fish. Many people do not relish the blood red colour of the flesh of Tuna. But as cured fish it has a good value in Ceylon.

" Masi " or " Maldve Fish " is a special preservative preparation of the Tuna flesh. By this, the flesh is cut into fillets of about $8'' \times 2'' \times 2''$ and are half-cooked in steam. Then these are rolled in salt water or salt and kept in canvas or gunny and twisted to squeeze out the water content. Then they are kept in grills and smoked to dry. A well prepared " Masi " is light brown in colour, hard and fibrous. Cured Tuna in this way has a very high value in Ceylon and it is esteemed as a high delicacy by the Ceylonese.

" Masi " is prepared in small quantities at Kilakarai more for domestic use by experienced curers who have been in Ceylon before.

Proper exploitation of Tuna sp. have not been done in deeper waters. Study and information in this field is wanting.

With the aid of fast sea worthy decked boats, Drift Tuna line could be attempted from Tuticorin base. Tuna Drift lines baited with Mackerel or squid should be attempted during August–October in about 200 fathoms off Tuticorin or Kanyakumari Coast along commercial lines to assess the productivity of our seas for this fishery.

Bill Fish.

Bill fishes are usually deep water varieties and often occur along with the deep water Tuna. In the Madras State the sail fish and marlins do not form an important fishery because of the comparatively insignificant landings and the poor sale value. These fishes are caught both in the Coromandel and Gulf of Manar coasts in Trolling lines in grounds adjacent to deeper waters.

The common Bill Fish, *Istiophorus sp.* is landed in Gulf of Mannar during the months of September–November in trolling lines along with Tuna sp. Occasionally these are also landed in the drift nets by rolling in the webbing during October–November. The size range is about 5′–6′ weighing 65–90 lb. In the Coromandel coast, Sail fish, and marlins are landed occasionally in the trolling lines during August–September. This is popularly called "Olai Meen" or " Pani Meen " and the fishermen dread the fish because of its fierce snout which is likely to hurt them when the fish spins full speed on a line and is landed in the canoe.

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